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ENVIRONMENTAL ANALYSIS RECORD

FOR PROPOSED
GEOTHERMAL
LEASING

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OREGON

MEDFORD DISTRICT
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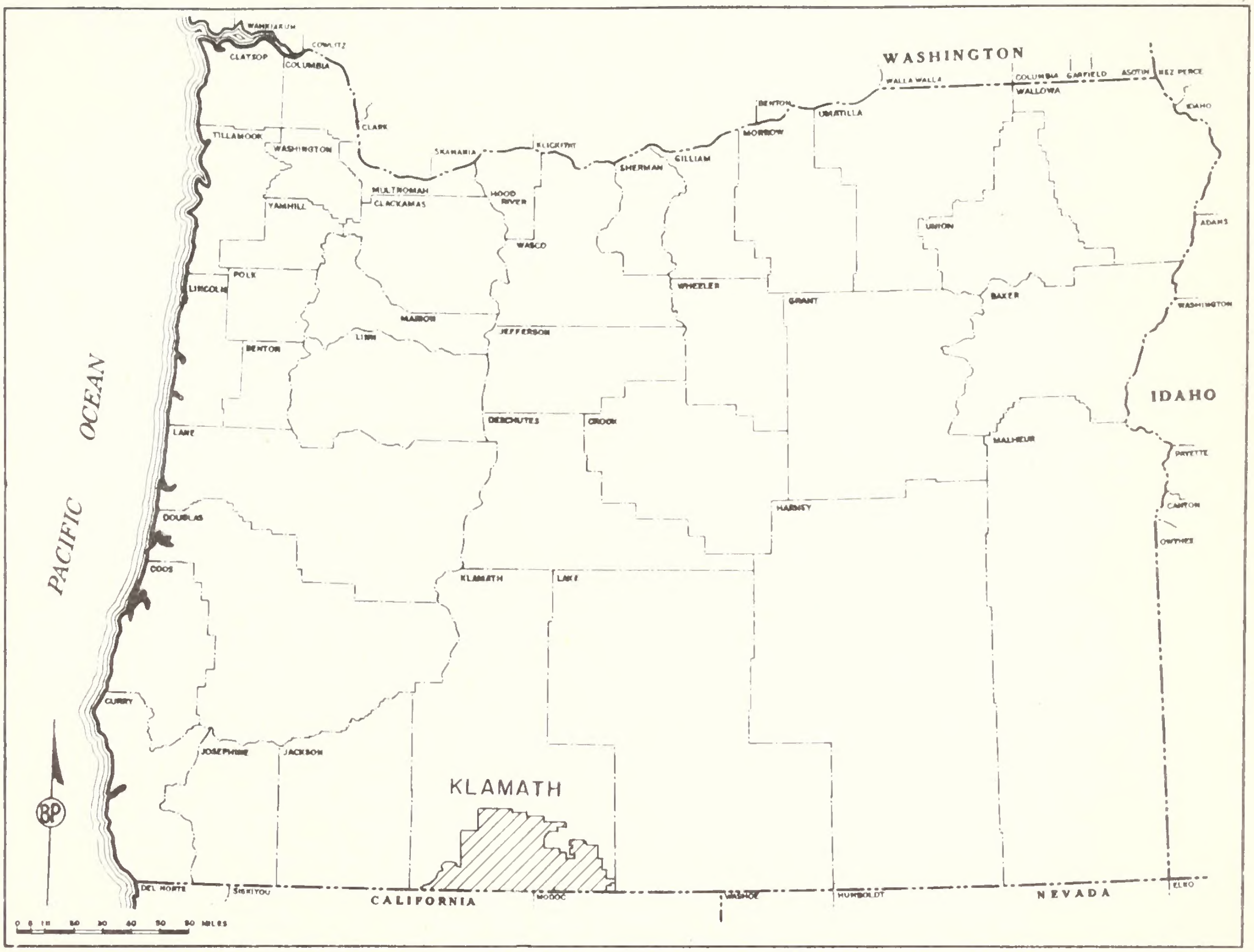
KLAMATH BASIN

Geothermal EAR Area ▨



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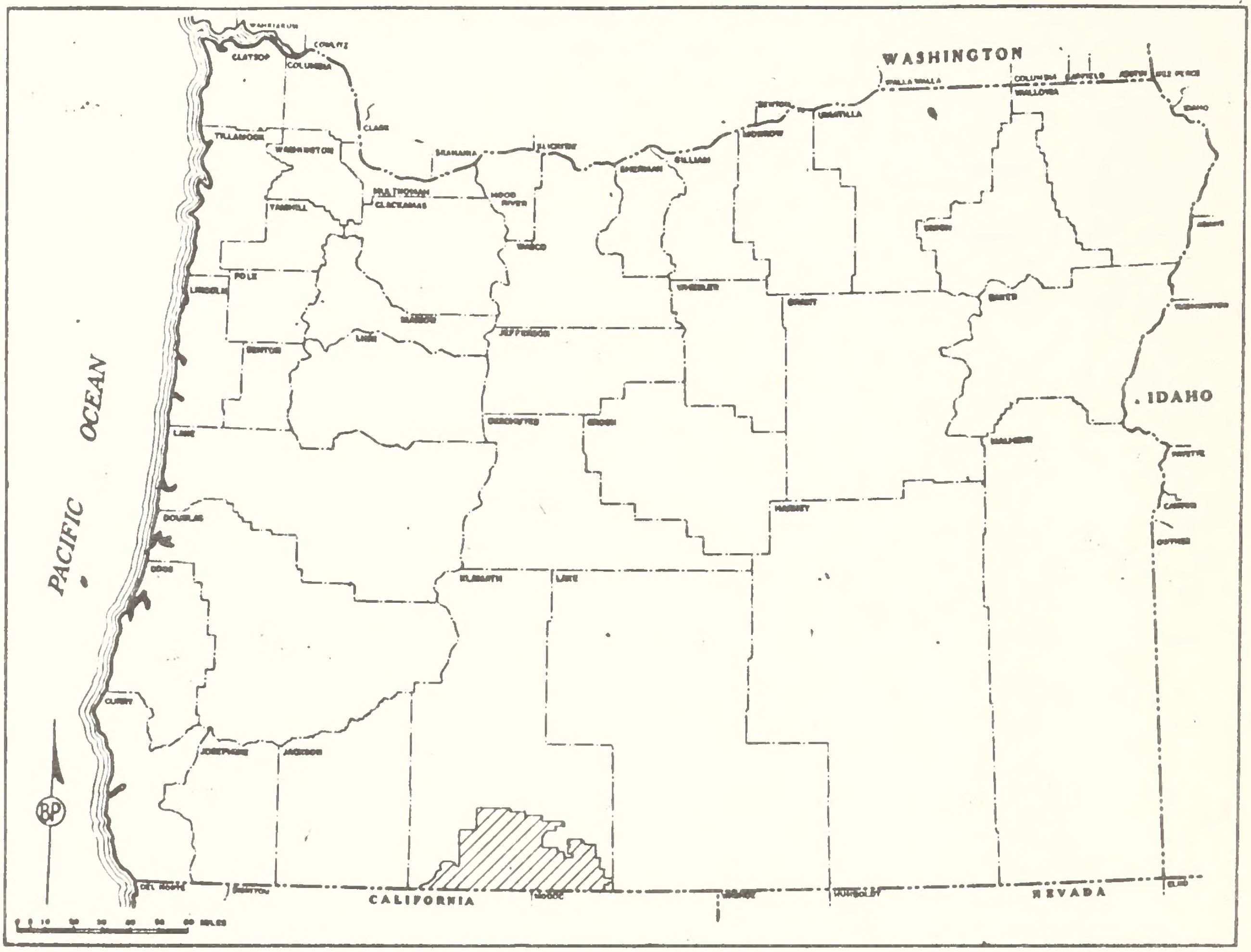
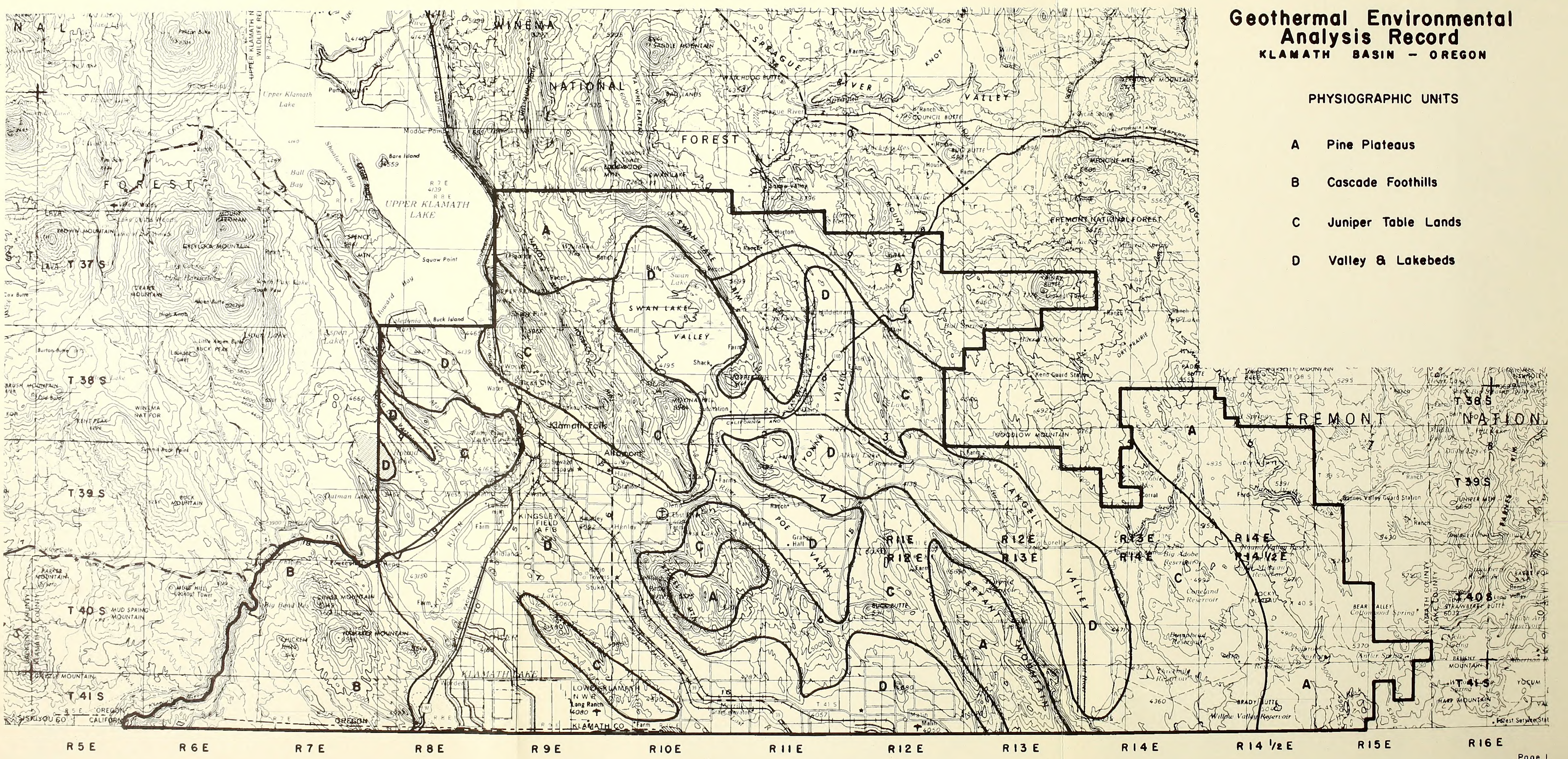
Geothermal EAR Area ▨



Geothermal Environmental Analysis Record

KLAMATH BASIN – OREGON



PHYSIOGRAPHIC UNITS

A	Pine Plateaus
B	Cascade Foothills
C	Juniper Table Lands
D	Valley & Lakebeds

Environmental Analysis Report

Klamath Basin

I. Description of Proposed Action

A. Introduction

The impact of proposed geothermal resource leasing on National Resource Lands in portions of the Lakeview and Medford B.L.M. Districts is analyzed in this Environmental Analysis Record (EAR). The total area under consideration includes approximately 650,000 acres in southern Klamath County of which approximately 450,000 acres are privately owned.

Federally administered lands are as follows:

B.L.M.administered:	Public Domain	- 157,000
B.L.M.administered:	O & C	- 14,053
B.L.M.administered:	Reclamation Withdrawal	- 8,910
Fish & Wildlife Service	Klamath Straits Refuge	- 5,500

The proposed action is for the leasing of B.L.M. administered lands so the main emphasis of this analysis is centered here. However, impacts could be felt on bordering land areas, so descriptions, impact analysis, and possible mitigating measures are presented after considering the entire land.

An interdisciplinary team of B.L.M. resource specialists from both districts prepared the analysis. This EAR is a supplement to and a specific extension of the Interior Department's "Final Environmental Statement for the Geothermal Leasing Program" (available in Interior Department offices, public libraries and from the Superintendent of Documents, U.S. Government Printing Office).

Information on the land and associated resources in the EAR were obtained from inventories and data furnished by federal, state, and local agencies and individuals having direct knowledge of the area. The basic data was recorded in B.L.M. inventory documents called Unit Resource Analyses (URA). Land use capabilities and potential resource conflicts are listed in a document called Management Framework Plan (MFP). Together, the two documents have inventories, conditions, uses, production, quality and management potentials for defined geographic areas of B.L.M. administered lands. The Lost River and Klamath URA and MFP contain information pertinent to this EAR area. These documents are available for review at the Lakeview and Medford District Offices.

The Klamath Known Geothermal Resource Area (KGRA) is located on the northwest boundary of the EAR area. "Known geothermal resource area" means an area in which the geology, nearby discoveries, competitive interests, existence of hot springs, or other signs would, in the opinion of the Secretary of the Interior, cause a belief in men who are experienced in the subject matter that the prospects for extraction of geothermal resources are good enough to warrant expenditures of money for this purpose.

Leasing of geothermal resources is regulated by the Geothermal Steam Act of 1970 (84 Stat. 1566); (30 USC 1001   1025). The act authorizes the Secretary of the Interior to issue leases for the development and utilization of geothermal steam and associated geothermal resources (1) in lands administered by him, including public, withdrawn, and acquired lands, (2) in any National Forest or other lands administered by the Department of Agriculture through the Forest Service, including public, withdrawn, and acquired lands, and (3) in lands which have been conveyed by the United States subject to the reservation to the United States of the geothermal steam and associated geothermal resources therein.

If lands to be leased under this Act are within any known geothermal resource area, they shall be leased to the highest responsible qualified bidder by competitive bidding under regulations formulated by the Secretary. If the lands to be leased are not within any known geothermal resource area, the qualified person first making application for the lease shall be entitled to a lease of such lands without competitive bidding.

B. Proposed Action

The Geothermal Steam Act involves the following actions:

(1) Approval of "Notices of Intent to Conduct Geothermal Exploration Operations. (Form 3200-9).

(2) Issuance of Non-Competitive Geothermal Resource Leases. (Form 3200-21).

(3) Issuance of Geothermal Resource Leases (Form 3200-12) by competitive bidding in KGRA and competitive interest areas.

Each of these actions contain built-in environmental safeguards in the form of regulations issued by the Secretary and partially reproduced in the report on pages 81 through 97. The Environmental Analysis Record analyzes the proposed action and alternatives in light of these requlations, and documents the analysis of the anticipated impacts upon the environment due to the proposed geothermal leasing and alternatives. Recommendations for mitigation and enhancement are made and incorporated in lease stipulations.

After this analysis and before any lease is issued the following actions will be taken.

A. Pre-Sale evaluation of specific tracts of land with in competitive lease areas to determine: (1) what tracts of land will not be offered for leasing. (2) what stipulations will be required to implement necessary mitigating measures on tracts to be offered, including identification of no surface occupancy areas.

B. Evaluation of specific tracts of land included in non-competitive applications to determine: (1) what tracts will be withheld from leasing. (2) what stipulations will be required to implement necessary mitigating measures on tracts to be leased, including identification of no surface occupancy areas.

After lands are leased, the lessee must submit a Plan of Operations before on-the-ground activity can begin. The plan is reviewed for compliance with applicable federal, state, and local regulations. In addition, the plan must be compatible with lease and land use permit stipulations of the geothermal regulations, recommendations developed in the EAR, and stipulations developed before the leases were issued.

C. Stages of Implementation

Four separate stages of implementation on a geothermal area have been identified. (For details see Appendix I)

1. Exploration - Includes all activities from the decision to explore for a geothermal field through the drilling of one or more "Wildcat" or exploration wells. The operations are:

   a. Airborne Exploration
   b. Off-road vehicular travel

   c. Road and Trail construction
   d. Drilling
   e. Rehabilitation

2. Development - This is the period of most intense activity. If the site is productive, development would include the following operations:

   a. Road Construction
   b. Drill Site development
   c. Geothermal Pipelines
   d. Plant Construction
   e. Electric Transmission Lines
   f. Rehabilitation

3. Operation - This phase is principally the production and maintenance interval. It includes the following operations:

   a. New Drill Sites
   b. Maintenance of existing facilities
   c. Waste Disposal
   d. Production

4. Close-out - This interval is the site abandonment phase. The operations are:

   a. Removal of Surface Equipment
   b. Capping drill holes and wells
   c. Surface reclamation and restoration

II. Description of the Existing Environment

A. Physiographic Units

The study area for this Environmental Analysis has been divided into units with similar environmental components such as plant life, soils and animals.

The identified units are shown on Map I.

1. Cascade foothills - The mixed pine, fir, cedar forests south and west of Keno to the Klamath River.

2. Pine plateaus - Ponderosa pine, juniper lands east of Gerber Reservoir, on Stukel Mountain and Bryant Mountain.

3. Juniper tablelands - Juniper, sagebrush hills between the valley bottoms and the pine plateau's.

Juniper Tablelands

4. Valley bottoms - Generally the tillable land with deeper soils and greater plant growth potential. Also included are the lakebeds which fill with water and support a lush growth of aquatic plant life during the summer months.

B. Geology

The EAR area contains a series of five major downthrown fault blocks or grabens which form Langell, Poe, Yonna, Swan Lake, and Klamath Valleys. There are five major upthrown fault blocks or horsts which form Bryant Mountain, Stukel Mountain, Naylox-Hogback Mountain, Swan Lake Rim and Klamath Hills. The plateau area east of Langell Valley and the upland area west of the Klamath Valley (Hamaker Mountain, Chase Mountain, and Chicken Hills) complete the general geologic makeup of the EAR area.

The main structural features are the horsts and grabens mentioned above. These structures are bounded by faults that trend about N 30° W and intersect a weaker set of faults that trend generally northward. Donath (1962) discusses this pattern of faulting in the vicinity of Summer Lake northeast of The EAR area. These fault systems form a rhombic pattern, especially in the area of Stukel Mountain. The faults of both sets were comtemporaneous and movement occurred concurrently along both sets (Donath 1962). Peterson and McIntyre (1970) group the faults of the area into two systems based on relative geologic age, general strike trend and amount of displacement. Their groupings roughly paralled Donath's two directions of faulting but they disagree on the relative age of each fault group.

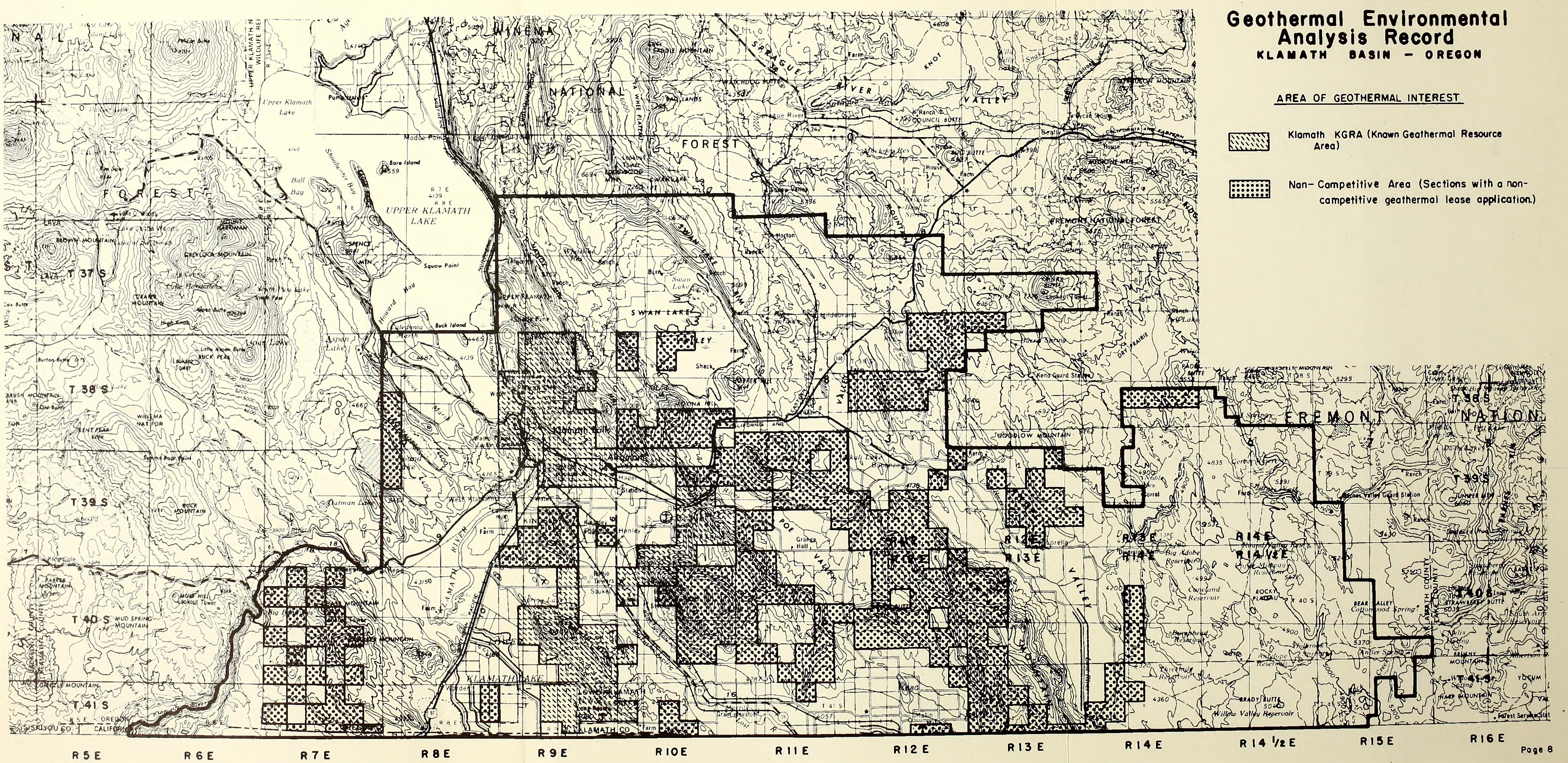
Rocks of Tertiary age in the EAR area consist of basalt flows, tuffaceous siltstones and sandstones, and tuffs and breccias. Rocks of later Tertiary-early Quarternary age include rhyodacite to andesite extrusives, basalt flows, basalt cinders, and basalt breccias and agglomerates. Deposits of Quaternary age consist of thin basalt flows and fluvial, alluvial, and lacustrine sediments (Peterson & McIntyre, 1970).

The Cascade foothills, pine plateaus, and juniper table lands are situated on the horsts while the valley bottoms occupy the grabens.

The Cascade foothills, in the area of Chase Mountain, Hamaker Mountain, and Chicken Hills consist primarily of basalts flows, breccias, and agglomerates. The basalt on the hill east of Hamaker Mountain and north and northwest of Chase Mountain are underlain by Tertiary fluvial and lacustrine

MAP 2

Geothermal Environmental Analysis Record
KLAMATH BASIN - OREGON



AREA OF GEOTHERMAL INTEREST

▨ Klamath KGRA (Known Geothermal Resource Area)

░ Non-Competitive Area (Sections with a non-competitive geothermal lease application.)

sediments. Hamaker Mountain, Chase Mountain and the hill east of Hamaker Mountain are Tertiary-Quaternary age basalt eruptive centers intruding both the sediments and the basalt flows. The area north of Chase Mountain has a tuff ring deposit which has intruded the basalt (Peterson & McIntyre, 1970).

The valleys, including Round Lake, Long Lake, Klamath, Swan Lake, Poe, Yonna, Langell and numerous small lakebeds are filled with Quaternary age alluvial sediments.

Pine plateaus and juniper tablelands are so similar in geology that they are described as one unit.

The plateaus east and north of Langell Valley consists of Tertiary age basalt flows overlain by Quaternary basalt flows and intruded by basaltic eruptive centers. The area around Stukel Mountain, Buck Butte, and Bryant Mountain consists primarily of Tertiary fluvial and lacustrine sediments intercalated with basalt breccias and tuffs which are overlain by basalt flows, breccias, and agglomerates. There are some Tertiary tuff ring deposits northeast of Stukel Mountain and basaltic cinder cones east of Bryant Mountain. There are also some Quaternary basalt flows overlying the Tertiary sediments east and northeast of Stukel Mountain, and north of Bryant Mountain (Peterson & McIntyre, 1970).

The Short Lake area, north of Bonanza, consists of fluvial and lacustrine sediments intercalated with basalt breccias and tuffs which are overlain by Quaternary basalt flows. Yainax Butte is a Tertiary-Quaternary basalt eruptive center which appears to have intruded Quaternary basalt flows. The south end of Bly Mountain is composed of extrusive rhyodacite and a coarse glassy andesite. The extrusive is abutted by a basalt flow and is underlain by Tertiary fluvial and lacustrine sediments (Peterson & McIntyre, 1970).

The plateau area around Swan Lake Rim, Naylox Mountain, Plum Hills, Moyina Hill, and Hogback Mountain consists primarily of fluvial and lacustrine sediments intercalated with basalt breccias and tuffs. Around Swan Lake Rim, Plum Hills, and the hill north of the Poe Valley these sediments are overlain by basalt flows, breccias, and agglomerates which, in turn, are intruded by a Tertiary - Quaternary basalt eruptive center. Moyina Hill, Naylox Mountain, and the area northwest of Swan Lake Valley have basaltic eruptive centers intruding the Tertiary sediments. A few places at the south end of Swan Lake Rim and on Hogback Mountain, the Tertiary sediments are overlain by Quaternary basalt flows. There are also a few places in Yonna Valley and on the east side of Hogback Mountain with Tertiary tuff ring dieposits. The west side of Hogback Mountain and the east side of Naylox Mountain have some Quaternary lacustrine terrace deposits (Peterson & McIntyre, 1970).

The Klamath Hills consist of basalt flows underlain by fluvial and lacustrine sediments interbedded with basalt breccias and tuffs. The southeast end of the hills has a tuff ring deposit intruding the sediments. The hills southeast of Wocus Marsh consist of Tertiary fluvial and lacustrine sediments. These rocks are overlain by basalt flows, breccias, and agglomerates, and intruded by a Tertiary-Quaternary basalt eruptive center (Peterson & McIntyre, 1970).

The hills around Round Lake consist primarily of Tertiary-Quaternary basalts flows, breccias, and agglomerates. The basalts in the hills south of Round Lake are underlain by fluvial and lacustrine sediments intercalated with basalt breccias and tuffs. The basalts in the hills north of Round Lake are intruded by a Tertiary-Quaternary basalt eruptive center. There is a basaltic cinder cone on the north end of Wocus Marsh (Peterson & McIntyre, 1970).

Many hot springs and hot wells are located in the Klamath Basin on private land. Below is a list of hot springs and wells (Waring, 1965; Bowen & Peterson, 1970; Lund, Culver & Svanevik, 1974; and Storey, 1974):

No.	Name & Location	Temp (^{o}F/^{o}C)	Flow (gpm/lpm)[1]	Remarks
1	Klamath Hot Springs (T. 38S., R. 9E., Sec. 28)	185/85	150/568	Original hot springs are gone. Siliceous tuff present.
2	Klamath Falls Well Area (T. 38S., R. 39S., R. 9E.) Ponderosa J. High School Mazama Mid-High School Boy Scout Building Ponderosa Nursing Home K. Falls Main FIres Station Balsiger Motor Co. Municipal Swimming Pool Main Street Apartments Roosevelt Apartments Presbyterian Intercommunity Hospital Oregon Institute of Technology (6 wells) Mills Elementary School Roosevelt Elementary School Calhoun's Floor Covering MedoBel Dairy	70-250/21-121	Individual flows from 25-400/95-1514. Total flow is unknown.	About 400 wells. Depth of wells vary from 90' artesia wells to 1805' deep wells.

---

[1] (gpm/lpm) = gallons per minute/liters per minute

No.	Name and Location	Temp. (°F/°C)	Flow (gpm/ lpm)	Remarks
3	Holiday (T. 39S., R. 8E., Sec. 13)	70/21	50/189	
4	Hardbound Spring (T. 39S., R. 9E., Sec. 18)	70/21	135/511	
5	Klamath Hills Well Area (T. 40S., & T. 41S., R. 9E.)	80-186/ 27-86	Total about 5000/18,927	About 10 wells; silicification prevalent in the area.
6	Olene Gap Springs (T. 39S., R. 10E., Sec. 14)	165/74	100/379	Has an orifice in Lost River
7	Roenicke Hot Springs (T. 39S., R. 10 E., Sec. 14)	158/70		
8	Crystal Spring (T. 39S., R. 10 E., Sec. 22)	78/26	1350/5110	
9	Taylor Warm Spring T. 39S., R. 11½ E. Sec. 19)	75/24	3150/11924	
10	Bonanza Well (T. 39S., R. 12 E., Sec. 19)	200/93	?	Hit hot water at 3850'.
11	Fiegi Well (T. 40S., R. 11 E., Sec. 3)	83/28	?	
12	Fry & Barney Well (T. 41S., R. 12E., Sec. 12)	73/23	600/2271	
13	Turner Hot Spring (T. 40S., R. 13E., Sec. 10)	148/64	40/151	
14	Smith Hot Spring (T. 40S., R. 13E., Sec. 10)	146/63	5/19	
15	Wilkerson's Hot Spring	76/24	25/95	Two orifices

The hot springs in the area of Klamath Falls were first used by Indians as winter campsites and for cooking and bathing. A greenhouse and swimming pool were the primary use of the hot springs in Klamath Falls in the early 1900s. In recent years shallow wells have been drilled to utilize the hot water for space heating in homes and businesses (Peterson & Groh, 1967). To date about 400 wells have been drilled to depths between 90' and 1805' and have encountered water with temperatures between 70° and 250°F (Lund, Culver & Svanevik, 1974).

Hot water wells in the area south of the Klamath Hills have encountered 200°F water flowing 1000 gpm at 285' and 186°F water flowing 450 gpm at 418'. Other wells in this area have also encountered hot water at somewhat lesser volumes (Peterson & McIntyre, 1970).

Olene Gap Hot Springs have a surface temperature of 165°F and an estimated subsurface reservoir temperature of about 176°F (Mariner and others, 1974). Olene Gap Hot Springs issue from Tertiary-Quaternary basalts and associated pyroclastic rocks.

The geologic and hot spring data indicate that the area with the greatest potential for geothermal resources should be in the Klamath Valley and the hills immediately around the valley, see Map 2. Specifically those areas would be Klamath Falls, Hogback Mountain, Olene Gap, the ridge south of Olene Gap, Stukel Mountain, and the Klamath Hills. Areas with minor geothermal potential would be Poe and Langell Valleys.

Seismic activity in the area has been reported as long ago as 1867 in the Fort Klamath area, 30 miles north of Klamath Falls. The only seismic activity reported since then are several small earthquakes in the period from 1947 to 1951. During mid-October of 1947, three small shocks occurred at Fort Klamath. Two months later, in December, 1947, a small shock occurred at Klamath Falls. The largest shock in the area occurred three months later, in March 1948, at Hildebrand. The last events during this period were three small shocks in April 1949, December 1949, and April 1951 at Klamath Falls (Berg & Baker, 1963, and Couch & Lowells, 1971).

Five exploratory oil wells were drilled on private land in the EAR area prior to World War II. No oil or gas shows were found, but hot water was encountered in two of the wells. The deepest well, drilled near Bonanza, is 4365' (1330 m) deep (Peterson & McIntyre, 1970).

There are several diatomite prospects, most on private land, in the central part of the EAR area. All but one of the prospects is in the diatomite facies of the Tertiary lacustrine sediments. The Tertiary diatomite occurs as a 240' thick unit of diatomite mixed with clay and ash. Because diatomite outcrops are scarce, most of the better diatomite indications are found in water well drill holes (Peterson & McIntyre, 1970).

There are two cinnabar prospects in the area, but none on Federal land. The prospect near O.I.T. consists of minor disseminated cinnabar in layered opal and agate of hot spring origin. The prospect in the Klamath Hills also consists of minor disseminated cinnabar in agate and opal of hot spring origin. Neither prospect has produced any mercury (Peterson & McIntyre, 1970).

There is one perlite prospect on private land at Bly Mountain. According to Peterson and McIntyre (1970), the expansion properties of the perlite are not good.

Material sites with cinders, scoria, sand, gravel, and construction stone are scattered throughout the area. These materials, used primarily for roads and construction appear to be in abundant supply. There is building stone in the area, but the market distance is too great to encourage their development. There is some poor quality clay in Klamath Falls when mixed with good clay is suitable for making bricks (Allen & Mason, 1949).

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C. Soils

The area under study contains one bottomland and four upland soil associations as outlined in the Klamath Basin General Soil Report of the Soil Conservation Service of 1967.

Generally the soils range in depth from shallow (10-20 inches) over bedrock on mountain side-slopes to deep (over 60 inches) on fans, terraces , and old lake bottoms.

Soils of the Juniper tablelands are very shallow, stony, cobbly clay loam. The erosion hazard becomes critical when vegetation and surface soil structure is disturbed. These soils are associated with low moisture and do not rehabilitate easily.

The pine plateaus contain soils that are well drained stony clay loam. Erosion hazard is moderate depending upon slope and the degree that vegetation was removed.

The valley bottoms have deep soils that are fine grained silty clay loam. These soils are generally poorly drained, expecially the lakebeds, and have a very low erosion hazard.

The soils of the Cascade foothills are moderately deep, very cobbly and well drained. The gravelly clay loam soils support a dense cover of brush and trees. Erosion hazard is slight to moderate depending upon the slope and amount of surface vegetation removed. For a more detailed soils analysis refer to the Klamath Basin General Soil Report or to individual soil association interpretation reports in the Lost River URA file.

D. Land Use

The land base supports uses ranging from livestock and wildlife grazing to the densely populated urban area of Klamath Falls. Uses include livestock grazing, many types of recreation, irrigated agriculture and a multitude of man-made improvements. The majority of the developed land is located in the valley bottoms and in the tableland areas. These areas contain the majority of Klamath County's population.

Valley bottoms are mostly privately owned and used for agriculture. Most of the valley areas have a developed system of canals supplying water for flood or sprinkler irrigation systems. Hay crops (includes alfalfa, clover, small grains cut for hay, and wild hay) are the most important agricultural crop produced. Potatoes rank next in importance followed by small grains. Swan Lake Valley, Poe Valley, Langell and Yonna Valley are primarily irrigated pasture, hay, and small grain areas. Farmers in the Spring Lake Valley area and the area around Merill and Malin produce potatoes in addition to hay and grain.

The tablelands are primarily rangeland areas and are often used in conjunction with farming operations in the valley floor. Rock quarries and gravel pits in this area are an important source of building material. This land use is particularly important along the base of Stukel Mountain and on Windy Ridge near Bonanza.

There are numerous structures in the valleys and foothills, ranging from roads and railroads to highly developed urban, commercial,

The Lost River Valley between Bonanza and Olene.

and industrial areas. The lower elevation areas contain numerous rural homesites and the rural communities of Bonanza, Dairy, Olene, Worden, Merrill, Malin, Lorella, and Keno. The city of Klamath Falls and its suburbs are also within the valley floor. The valley floor and tablelands also have several recreational type subdivisions. An example of this type of subdivision in the pine plateau is found on Bly Mountain.

The Klamath Straits unit of the Tulelake Refuge and numerous private fields south of Klamath Falls are important waterfowl hunting areas. The foothills, tablelands, and plateaus receive heavy hunting pressure during deer season. Other recreational land uses include a wide variety of diverse interests, ranging from bird watching to hang gliding from Stukel Mountain.

The primary land use in the Cascade foothills and pine plateaus is timber production. Specific timber areas include Bryant Mountain, Stukel Mountain, Chicken Hills, Chase Mountain, and Hamaker Mountain. Communication sites constitute an important land use on several high peaks. There are communication sites located on Hamaker Mountain, Yainax Mountain, Buck Butte, Brady Butte, Moyina Hill, Hogback Mountain, Stukel Mountain, and Bryant Mountain.

E. Air

1. Particulate Matter

The total suspended particulates are monitored in Klamath Falls and at O.I.T. Campus. The particulate concentration in Klamath Falls averages 80 micrograms/cubic meter, slightly higher than Oregon's ambient air quality standard (60 micrograms/ cubic meter of air, as an annual mean). The particulate concentration at O.I.T. Campus averages 38 micrograms/cubic meter, well below Oregon's ambient air quality standard (see table on page 20).

The four primary contributors of particulates to the air are nature, agriculture, industry, and the community. Nature and agriculture are the two largest contributors of particulate matter. They contribute soil dust and pollen during the late spring, summer, and early fall. Trees, grain, and hay are the primary sources of pollen, while dry lakebeds, barren fields, and unsurfaced roads are the primary sources of soil dust.

Industry contributes soil dust, smoke, and wood dust to the air throughout the year. Smoke and wood dust originate

Ponderosa Pine occupy the plateaus east of Klamath Falls.

at the lumber mills, while the primary sources of soil dust are unsurfaced roads, rock crushing operations, and other industrial activities.

The community contribution to air pollution is mostly smoke during the winter. The source of the smoke is from home heating units which burn wood or oil. The community also contributes soil dust from unsurfaced roads and exhaust from vehicles.

The particulate concentration varies with the weather. Dry summer winds increase the dust and pollen concentrations, and winter air inversions increase smoke concentrations.

The particulate concentrations are generally greater in the valley bottoms, where they originate, then on the pine plateaus, juniper tablelands, and Cascade foothills.

2. Noxious Gases

The primary source of noxious gases in the EAR area is automobile exhaust (carbon monoxide, hydrocarbons, nitrogen oxides, and some sulfur dioxide). The area with the highest concentration is Klamath Falls, which averaged 13.1 micrograms/cubic meter SO over a 1½ year period (the other noxious gases were not measured). This SO concentration is about the lowest amount detectable in air, and well below Oregon's ambient air quality standard (60 micrograms/cubic meter of air, as an annual man).

Noxious gases (carbon monoxide and hydrocarbons) are also emitted by the burning of mill waste, heating fuels (wood and oil), forest slash, and other types of waste.

Hydrogen sulfide is dispersed into the air by some of the hot springs within the area. Concentrations range from 0.03 to 0.002 ppm in the immediate vicinity of the springs.

3. Air Movement Patterns

Prevailing winds are from the west and south with occasional breezes from the north during late summer. The west wind, which prevails during spring and early summer, averages 6.2 mph. The south wind, which prevails during late fall and winter, averages 5.8 mph. The north wind, which prevails during the late summer and fall, averages 4.6 mph.

Thunderstorms usually come from the southwest and exhibit no prevailing wind direction. They occur in the spring

Table 1

Particulate Data*

Mean Annual Particulate Concentration (micrograms/cubicmeter)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Ave.
Klamath Falls	86.3	87.7	72.0	82.3	72.1	72.3	76.8	84.9	85.8	83.6	67.9	89.0	80.0
O.I.T. Campus	63.4	45.4	31.5	39.2	27.3	26.1	42.5	41.9	37.2	35.0	27.6	31.9	37.8

*Information collected by Oregon Department of Environmental Quality and summer and are the source of the strongest summer winds. The winter storms come from the west and have strong southerly winds.

The daily winds in the area commonly begin in the late morning and end in the late afternoon. On hot days, dust devils (small tornadolike storms) are common in the valleys.

Valleys are susceptible to air temperature inversions throughout the year. Inversions are more common during the summer than the winter, but the winter inversions are usually stronger (greater temperature difference from the base to the top). Because of the strength of the inversions, the winter inversions usually break up in the mid-afternoon while the summer inversions break up by late morning.

The major effect of an inversion is to increase the concentration of pollutants near the ground. The dispersion of pollutants is prevented because a cool air mass in the valley is trapped beneath a warmer air mass and results in almost no air circulation.

F. Temperature

Valleys usually have about 97 frost-free days, and average 64.5°F in the summer and 31.8°F in the winter. The temperature extremes in the valleys are from 97°F in the summer to -4°F in the winter. Daily temepratures vary about 32°F in the summer and 17°F in the winter.

The Cascade foothills, pine plateaus, and juniper tablelands usually have about 45 frost-free days, and average 57°F in the summer and 29°F in the winter. The temperature extremes are from 89°F in the summer to 6°F in the winter. Daily temperatures vary about 32°F in the summer and 17°F in the winter.

G. Non-Ionizing Radiation

Non-ionizing radiation in the EAR area is emitted primarily from microwave, television and radio transmitters, telephone and electric transmission lines, and radar installations. These radiation sources are usually located near towns or on top of ridges.

Radar installations are located at Klamath Falls Airport and Hamaker Mountain, while microwave relay stations and transmitters are operated at Klamath Falls, Bonanza, Hamaker Mountain,

Table 2

Climatological Data*

Mean Annual Temperature (F°)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Ave.
Klamath Falls	29.8	34.8	39.1	45.9	53.0	59.5	68.0	66.1	60.0	49.7	38.7	32.4	48.1
Malin	29.7	34.7	37.1	41.8	52.9	60.2	67.1	66.3	57.9	46.9	38.5	29.6	46.9

Mean Wind Data at Klamath Falls Airport

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep/	Oct.	Nov.	Dec.	Ave.
Prevailing Wind Direction	SSE	SSE	W	W	W	W	W	NNW	NNW	NNW	SSE	SSE	W
Average Wind Velocity (mph)	6.6	5.9	7.3	6.7	6.2	5.8	5.0	4.5	4.4	4.8	5.5	5.1	5.7

*For more detailed information on the climate, refer to the respective District's Climatological file, or the U.S. Weather Station at the Klamath Falls Airport.

Hogback Mountain, Brady Butte, and Buck Butte. Commercial and private radio transmitters and repeaters are found at Klamath Falls, Malin, Merrill, Klamath Falls Airport, Hamaker Mountain, Hogback Mountain, Stukel Mountain Chase Mountain, Radio Hill, Yaniax Butte, Bryant Mountain, and other hills and towns in the EAR area. There are also many mobile radio units in the area. Television transmitters and translators are located at Klamath Falls, Stukel Mountain, and Hogback Mountain.

Radio, television, and microwave transmitters operate at various frequencies with outputs from 1 to 30,000 watts. The radar installations operate with a power output from 2 to 5 megawatts.

There are many telephone and electric transmission lines crossing the area which emit non-ionizing radiation at various frequencies and power levels. These trasmission lines are concentrated in towns and along routes between towns.

The electric transmission lines which emit the most non-ionizing radiation in the EAR area are two 500 KV alternating current lines running from Beatty to Malin via Bonanza and the north end of Bryant Mountain.

H. Water

1. Hydrologic Cycle

Water in the Klamath Basin originates as precipitation with the majority of it falling during the period of October through March. December and January receive the maximum and the minimum occurs during July, August, and Septmeber. (See table 3 on page 24.)

The juniper tablelands and pine plateau areas receive most of the precipitation in the form of snow. Mid-winter rains occur frequently at the lower elevations.

Precipitation can be divided into three categories once it has reached the earth's land surface: (1) surface runoff, (2) evaporation and transpiration losses and (3) seepage into the ground (recharge).

Surface runoff is by rivers such as Klamath River and Lost River. They are fed through snow melt, rain and discharge from springs.

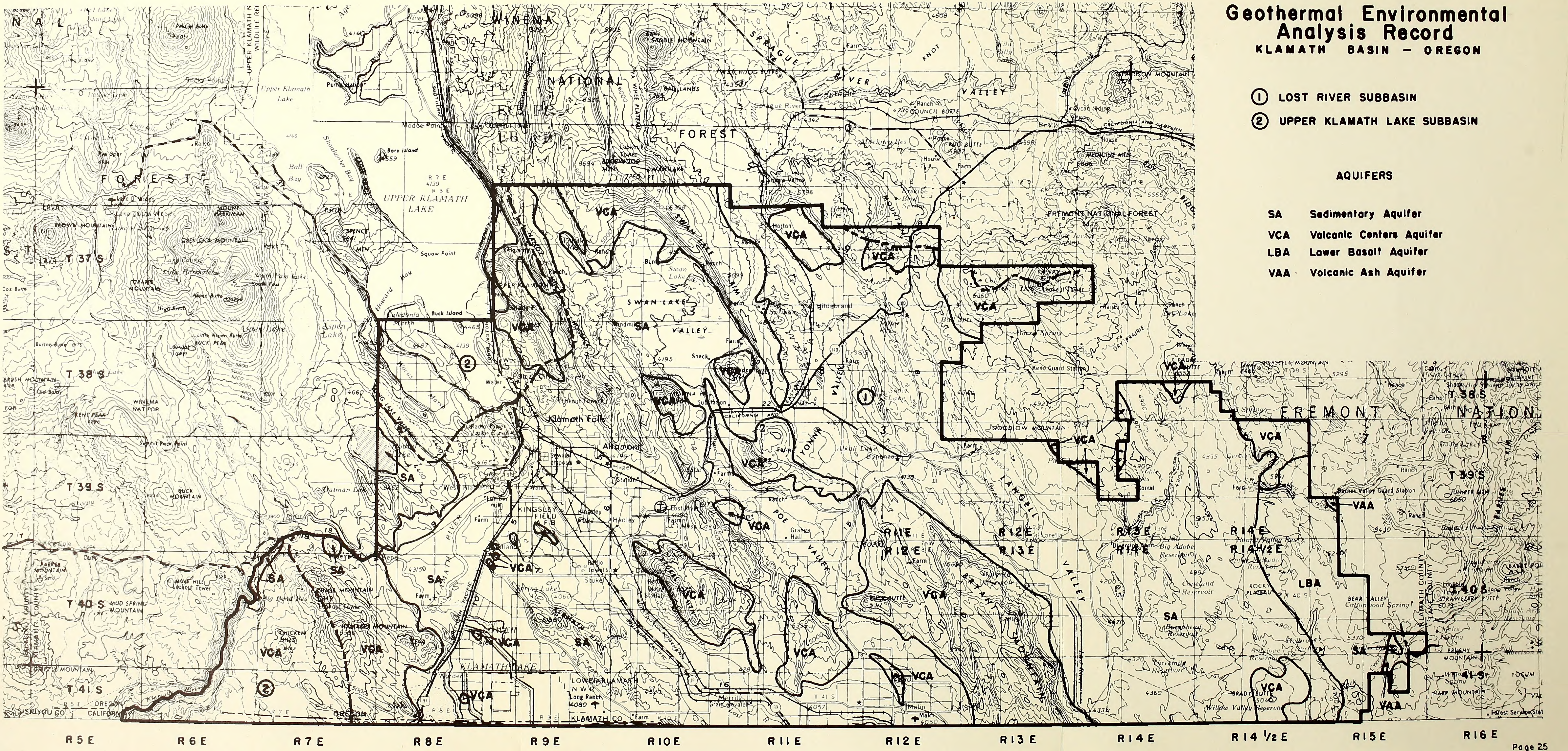
Evaporation and transpiration occurs from lakes, from the

Table 3

Average Precipitation*

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Klamath Falls	2.11	1.56	1.24	0.84	1.15	0.95	0.31	0.33	0.60	1.15	1.61	2.21	14.06
Malin	1.83	1.02	1.69	0.82	1.16	0.66	0.29	0.18	0.59	1.40	1.72	1.98	13.34
Keno	3.03	2.23	1.82	1.08	1.39	0.93	0.31	0.32	0.68	1.70	2.36	2.94	18.79

*Climatological Data for Oregon, U.S. Department of Commerce.



Geothermal Environmental Analysis Record

KLAMATH BASIN - OREGON

① LOST RIVER SUBBASIN

② UPPER KLAMATH LAKE SUBBASIN

AQUIFERS

SA	Sedimentary Aquifer
VCA	Volcanic Centers Aquifer
LBA	Lower Basalt Aquifer
VAA	Volcanic Ash Aquifer

soil and by vegetation. Evapotranspiration data on the vegetated areas has been estimated to be 1½ feet/year from large stands of pine trees, and less than 1 foot from sagebrush and low lying open lands.

The remaining precipitation that is not lost percolates into the ground water table. Ground water flows through spaces between rocks or fractures. These spaces are generally less than 1 inch in diameter. Ground water can be found in four different aquifers. (See map 3.)

Sedimentary Aquifer - stream and lake deposited silt, sand, clay, gravel, peat, chalk, and ash, volcanic ejecta, thin basalt and andesitic lava flows. Specific capacities completed in this unit range from 0.01 to 5 gallons per minute per foot of drawdown and average 0.45 gallons per minute per foot. Some black sand and gravel layers may yield 2-10 gallons per minute per foot of drawdown.

Volcanic Centers Aquifer - moderate to highly fractured basaltic, dacitic and andesitic lava flows and pyroclastic material associated with eruptive centers. Specific capacities of wells completed in this unit range from less than one to over 100 gallons per minute per foot of drawdown and average approximately 25 gallons per minute per foot of drawdown.

Lower Basalt Aquifer - highly faulted and fractured series of basaltic lava flows separated by layers of scoria and cinders. Specific capacities of wells completed in this unit range from 35-500 gallons per minute per foot of drawdown and average about 145 gallons per minute per foot of drawdown.

Volcanic Ash Aquifer - massive beds of light colored rhyolitic and dacitic ash flows; minor amounts of basalt and volcanic sediments. Specific capacities are largely untested as well logs have not reported this unit within the Klamath Basin. This unit lies below lower basalt aquifer and at considerable depth. See map 3 for location and extent of the acquifers.

There are many wells located in the area, however, to date no serious decline in water levels has occurred. This is evidenced by observation wells. Annual water level flucations are greater in wells located in the recharge areas than those in the discharge areas. (See map 4 for recharge and discharge area locations.)

Water quality is the highest in the recharge areas and declines in quality as it flows toward the discharge areas. Temperatures correspond to quality with the recharge area having the coldest water. Water in wells in the recharge areas have low temperatures of 40 F to 50 F and have small quantities of dissolved chemicals. (See tables for water quality on pages 30 and 31.)

There are several localities within the Klamath River Basin that have geothermal groundwater. The larger more developed area is in northeastern Klamath Falls. In 1975 there were approximately 400 wells utilized for heating purposes. The depth of these wells range from 100 feet to approximately 1800 feet. Temperatures average less than 190 F. (See geology section for well data.)

2. Lost River Subbasin

The Lost River Subbasin is a naturally closed basin. The river originates at the outlet of Clear Lake in northeastern California and drains the eastern 90% of the area considered in this analysis.

Lost River enters Oregon at the southeast end of Bryant Mountain flowing northwesterly on the west side of Langell Valley, continuing westward to the northern end of Poe Valley. It enters Klamath Valley through Olene Gap flowing southward along the east side of Klamath Valley and eventually discharging into Tule lake in northeastern California. (Gaging stations locations and date are shown on Pages 32-34.)

Other main sources of water contributing to the Lost River drainage system are Gerber Watershed with an average runoff of 50,000 CFS and Bonanza Spring producing 100 cubic feet/sec. A diversion was made between Lost River and Klamath River for flood control and irrigation purposes. The Lost River Subbasin includes the following five valleys: Langell, Yonna, Swan Lake, Poe, and Klamath. The regional water table of these valleys is generally the Lost River. The river apparently is the local base level for ground water moving beneath these valleys.

Perched water tables occur above the regional water table, are evidenced by springs in the juniper tablelands and pine plateaus area. Flow from these springs may vary from less than 1 gpm to several hundred gpm.

WATER SUPPLY

Table 4

WATER QUALITY - DRAINAGE INTO KLAMATH RIVER BETWEEN LINK RIVER DAM AND KLAMATH STRAIT DRAIN AND ASSOCIATED GROUND WATER

CONSTITUENTS	QUALITY
INORGANIC CHEMICAL CHARACTERISTICS	
1. Dissolved oxygen	1. Deficient for aquatic life.
2. Iron	2. Undesirably high for domestic municipal, and industrial uses.
3. Nitrogen	3. High concentration which enhances algae growth.
4. pH*	4. Alkalinity sometimes undesirably high for irrigation and aquatic life.
5. Phosphates	5. High concentration which enhances algar growth.
6. Sodium absorption ratio	6. Generally adequate for irrigation.
7. Specific conductance*	7. Generally adequate for irrigation. Some thermal ground water is undesirable for sensitive crops.
8. Total dissolved solid, including boron, chloride sodium sulfates. Thermal plus fluoride.*	8. Suitable for all uses, except water from thermal wells which may be unsuitable for domestic crops.
9. Water types.	9. Varies from Calcium-sodium bicarbonate to sodium-calcium bicarbonate.
MICROBIOLOGICAL CHARACTERISTICS	
10. Biological oxygen demand	10. Unsuitable for aquatic life.
11. Coliform organisms	11. Too high for public health and water-contact recreation without treatment.
PHYSICAL CHARACTERISTICS	
12. Temperatures	12. Deterimental for fish life during summer months.
13. Turbidity	13. Exceeds levels desirable for aquatic life. On the Link River main street bridge - 80 Jackson turbidity units have been recorded.

*Includes ground water.

The primary use of water is for irrigation of croplands in the Klamath Project area.

3. Upper Klamath Lake

The Klamath River drains only a small portion (approximately 10%) of the area considered in this analysis. The river flows from Upper Klamath Lake southward through Link River to Lake Ewauna. It flows from Lake Ewauna along the northwest side of Klamath Valley over lava ridges near Keno, descending through a deep canyon into California. It eventually reaches the Pacific Ocean. The major water source for Upper Klamath Lake is the Williamson River (outside of the analysis area) and many springs beneath it. The portion of the area considered in this analysis contributes only a minor portion of the Klamath River flow.

WATER SUPPLY

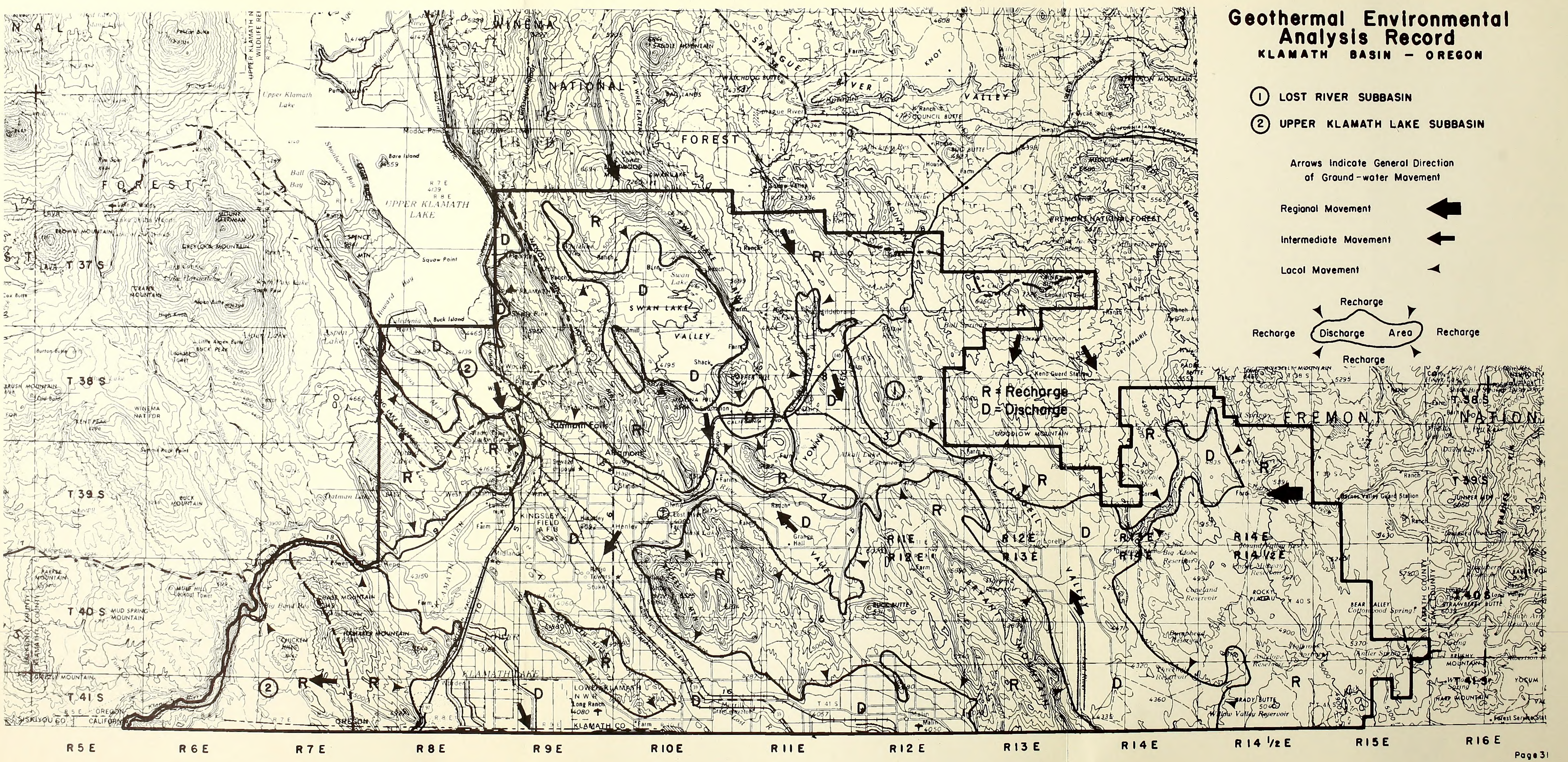
Table 4A

WATER QUALITY
DRAINAGE IN LOST RIVER AREA IN OREGON AND ASSOCIATED GROUND WATER

CONSTITUENTS	QUALITY
INORGANIC CHEMICAL CHARACTERISTS	
Oregon Portion (Lost River Area)	
1. Dissolved oxygen	1. Below concentration desirable for aquatic life in lower Lost River.
2. Iron	2. Exceeds level desirable for domestic, municipal industrial uses.
3. pH	3. Alkalinity often exceeds levels desirable for aquatic life.
4. Specific conductance*	4. Higher than desirable in some ground waters for sensitive crops.*
5. Total dissolved solids, including boron, chloride, sodium, sulfates.*	5. Generally suitable for all uses.
6. Water types: varies from calcium-sodium bicarbonate to sodium-calcium sulfate bicarbonate.	6. Calcium-sodium bicarbonate type is suitable for most uses. Sodium-calcium sulfate bicarbonate type may be of poor quality for domestic, municipal, and irrigation uses.
PHYSICAL CHARACTERISTICS	
7. Temperature	7. Frequently exceed levels desirable for aquatic life.
8. Turbidity	8. Often exceeds levels desirable for aquatic life. Turbidity as high as 123 JTU have been recorded 5 miles southeast on Bonanza.

*Includes ground water.

MAP 4



Geothermal Environmental Analysis Record

KLAMATH BASIN - OREGON

Table 5

Gaging Stations Located in the Subject Area

Station No.	Locations
11-5060	NE¼ Sec. 30., T. 38S., R. 9E., on left bank 300 ft. downstream from head gates of canal and 1 mile NW of Klamath Falls.
11-5070	NW¼SW¼ Sec. 19., T. 38S., R. 9E., at S.E. end of lake, 1.4 mile upstream from outlet and 2 5 mi. NW of main street B Bridge at Klamath Falls.
11-5075	SW¼NW¼ Sec. 32, T. 38S., R. 9E., on left bank 600 ft. upstream from outlet of Keno Canal.
11-5080	NE¼NW¼ Sec. 31., T. 39S., R. 10E., on south bank of Lost River Diversion Canal, 0.5 miles e. of bridge on St. Hwy 39.
11-5095	NW¼SE¼ Sec. 35., T. 39S., R. 7E., on left bank 1.7 mi. NW of Keno and 4.5 mi. upstream from Spencer Creek.
11-5107	SE¼SE¼ Sec. 14., T. 40S., R. 6E., on right bank 0.7 mi down stream from John C. Boyle power plant.
11-4860	SE¼SW¼ Sec. 29., T. 39S., R. 10E., on right bank, at head gates and 3.0 miles SW of Olene.

TABLE 6 - SUMMARY OF SURFACE WATER GAGING DATA ON THE LOST RIVER

Station No.	Water Year	Total Annual Discharge	Minimum Daily Discharge	Maximum Daily Discharge	Mean Daily Discharge
11-4860	1962	111,100 ac/ft	0 cfs	1,680 cfs	154 cfs
"	1964	121,900 ac/ft	"	891 cfs	168 cfs
"	1965	259,700 ac/ft	"	3,140 cfs	359 cfs
"	1967	117,300 ac/ft	"	1,890 cfs	162 cfs
"	1968	93,640 ac/ft	"	727 cfs	129 cfs
"	1970	*	*	*	*
	1971	*	*	*	*
	1972	*	*	*	*
	1973	*	*	*	*

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* Measurement not available

TABLE 7   SUMMARY OF SURFACE WATER GAGING DATA ON THE KLAMATH RIVER

Station No.	Water Year	Total Annual Discharge	Minimum Daily Discharge	Maximum Daily Discharge	Mean Daily Discharge
11-5107	1962	1,081,000 ac/ft	532 cfs	2,850 cfs	1,493 cfs
"	1963	1,422,000 ac/ft	618 cfs	5,310 cfs	1,964 cfs
"	1964	1,117,000 ac/ft	326 cfs	2,740 cfs	1,539 cfs
"	1965	2,132,000 ac/ft	340 cfs	8,730 cfs	2,945 cfs
"	1966	1,357,000 ac/ft	356 cfs	5,980 cfs	1,875 cfs
"	1968	919,300 ac/ft	317 cfs	2,720 cfs	1,266 cfs
"	1970	1,426,000 ac/ft	350 cfs	8,930 cfs	1,969 cfs
"	1971	1,857,000 ac/ft	374 cfs	8,510 cfs	2,565 cfs
"	1972	1,966,000 ac/ft	391 cfs	10,800 cfs	2,709 cfs
"	1973	1,161,000 ac/ft	351 cfs	4,140 cfs	1,603 cfs

Marsh areas are frequent from Upper Klamath Lake south to the Oregon border.

I. Plants (Aquatic)

The Klamath Basin contains one of the most diverse aquatic plant communities in the Pacific Northwest. Wet sites are found throughout the basin and not confined to one physiographic area.

1. Floating and vascular aquatic plants form an important food component for animals, both aquatic and terrestrial, within the study area. The more dominant vascular and floating plants identified are listed in appendix III.

2. Phytoplankton - Because of the shallowness of land and reservoir environments in the study area and warm summer temperatures, phytoplankton flourishes. Thirty-six species of plankton algae identified from Klamath Lake by Phinney and Peak 1959. These plants are common throughout the study area.

   Phytoplankton, responsible for the nuisance condition in Klamath Lake, are all members of the blue-green algal group (Cyanophyto).

   The distribution of bloom algae in Klamath Basin lakes is determined by wind drift, dilution effect of inflow water, chemistry of inflow water and currents.

   The oxygen relation of Klamath Lake and the Klamath River are precarious because of the organic load arising from the production of the bloom population. At times of peak population, when the drift starts to pile up organic material in shallow water along the southwest shore of Klamath Lake, oxygen replacement by all means may fail to keep up with the depletion due to respiration. Bullheads have been found dead in the shallows, apparently from oxygen starvation according to a study of Upper Klamath Lake by Phinney and Peak. Oxygen depletion due to plankton demand can occur in any of the lakes and reservoirs in the study area.

J. Plants (Terrestrial)

Vegetation on lands in pine plateau consist of a mixture of the juniper-sage type and the ponderosa-juniper type. Ponderosa pine is the dominant tree species, and is found in pure stnads or mixed with Western juniper. The pine grows in areas of

The mixed conifers of the Cascade Foothills are the major vegetative type west of Klamath Falls.

moderately deep soil, commonly along creek bottoms and north facing slopes. It is also found in "stringers" (narrow strips of pine forest), with rock flats of sagebrush, juniper, and grass between stringers. Understory vegetation may include squaw carpet, manzanita, forbs, serviceberry, mountain mahogany, chokecherry, bitterbrush, and native bunch grasses. Where fires have completely burned over a pine stand, dense brush fields of ceanothus and manzanita, like the ones on Stukel and Swan Lake Rim result.

Most of the pine forest has been partial cut once; many areas have been cut over twice. The main objective of these cuttings has been to leave a vigorous residual stand of pine timber by salvaging dead and dying trees and spacing trees for maximum growth.

There are isolated small tracts of lodgepole pine, quaking aspen, and white fir (notably on Yainax Butte). Incense cedar and Douglas-fir are found only in a few places.

A detailed list of major plant species is in appendix III.

Vegetation on the valley bottoms varies from agricultural crops to wet meadow plants to greasewood, sagebrush, and weeds on the dryer sites. The natural lakebeds trap runoff during the winter and spring and support a lush growth of rushes, sedges and weedy forbs. A wide array of aquatic plants grow in the areas that have water of greater depths.

The dryer portions of the valley bottoms support a dense community of big sage, rabbitbrush, wildrye, blue grasses and annuals.

Plants in the agricultural area have been discussed in the land use section.

Western juniper, sagebrush, rabbitbrush, bluegrass, Idaho fescue, and cheatgrass are the predominant form of vegetation of the Juniper tablelands. Juniper exists throughout the type and at times occurs in dense thickets. A variety of annual grasses and forbs mature as early as June, depending on the amount of spring moisture. The type has 8 - 10 inches of precipitation and is low in forage production.

The Cascade foothills have a vegetative cover of grasses shrubs and timber (both conifer and deciduous). The precipitation in the area (25 to 30 inches per year) is higher than that of the other areas included in this report. With the

increased precipitation the vegetative growth is lush and erosion is minimized. In the lower portions, 3600 to 4200 feet in elevation, the predominant species are native grasses, manzanita, wedgeleaf ceanothus, Western juniper and isolated ponderosa pine. With the increase in elevation the species composition changes to coniferous timber, consisting of Douglas-fir, white fir, ponderosa pine and incense cedar. Shrub species at this elevation are bitter cherry and wild lilac. These brush species will occupy the entire site if the timber overstory is removed by logging or by fire. The stream side vegetation at this elevation is represented by the same shrub species named above and deciduous trees; quaking aspen, black cottonwood and red alder. With a further increase in elevation, the conifer stands become predominately white fir.

K. Animals - Wildlife

Wildlife within the Klamath Basin and surrounding area is quite diversified. There are about 67 species of mammals, over 200 species of birds, and several species of fish, amphibians, and reptiles expected to be present in the area at times. A listing of these animals is presented in appendix II.

Information presented is based on data obtained from the Oregon Department of Fish and Wildlife and appropriate Unit Resource Analysis. More detailed data on species distribution and habitat is available in these URAs.

Mule deer are the primary big game species within the pine plateau unit. Bryant and Stukel Mountains support high density summer deer populations, with limited winter use on the lower slopes. The remaining areas provide a moderate amount of summer habitat, but are used primarily as transitional (spring-fall) range. This transitional range is utilized by a large number of animals, especially in the Gerber area which lies within the path of the interstate deer herd migration route. Fall movement to the winter range in California and southern Oregon usually begins in October. Following the winter, the return trip to the summer range is usually complete by May.

Research is currently in progress to determine the importance of transitional range to the mule deer population (refer to Interstate Deer Herd Study - Lakeview District Files).

This area receives heavy hunting pressure, which has increased over the past several years.

Antelope are present in the Gerber Reservoir area. Recent counts by the Oregon Department of Fish and Wildlife indicate a population of about 125 animals. These antelope move into the area in early spring for kidding and remain through the spring and summer, and return south to California for the winter. They concentrate in the open low sage flats and meadow areas. Kidding areas are shown on map 5.

An antelope archery season has been held here for the past three years, with 3 animals harvested.

The islands on Gerber and Round Valley reservoirs provide nesting habitat for Canada Gesse. Each year several broods are produced from these areas. The many other small reservoirs and potholes in this general area provide nesting and feeding sites for many species of waterfowl. Two active osprey nests are present in Gerber Reservoir and one Northern bald eagle nest is located at the mouth of Barnes Valley Creek. White pelicans utilize the north portion of Gerber Reservoir as a feeding area.

Sagegrouse are found in Dry Prarie and along the open areas surrounding Gerber Reservoir. Known strutting grounds are shown on map 5

Mourning doves frequent the openings throughout the type during the summer. The higher forest types contain habitat for Blue grouse. These birds are observed on Bryant, Stukel and Swan Lake Mountains. Cougars have been sighted on Stukel Mountain.

All of the timbered portions of the unit are utilized by cavity nesting birds, woodpeckers, sapsuckers, nuthatchers, and owls. Pilleated woodpeckers have been reported in this unit and a Spotted owl sighting was made north of the designated EAR area.

The Cascade foothills are a transition zone. Changes in dominant vegetation result in more diversity and an overlap between eastern and western Oregon animal species.

Mule deer and black-tailed deer are both present. Some hybridization has occurred. The higher elevation country is primarily summer range. Limited winter range is available along the Klamath River (map 5). This area is considered critical. The entire area receives heavy hunting pressure during the fall season.

Black bear, red fox, and ring-tailed cat are present here, although the latter are at the extremity of their range. The fisher was re-introduced into the Klamath area in 1959, and may be found here.

Known spotted owl, Bald eagle and osprey nests are located to the west of the EAR area (map 5). Elk are occasionally sighted in the higher areas.

An increased variety of forest birds inhabit this zone, as indicated by the species list (appendix II). Valley quail, blue grouse, and ruffed grouse are seasonal residents in the mixed confifer type.

Almost all of the Juniper tableland unit is mule deer winter or transitional range (map 5). A high percentage of the critical deer winter range within the basin is concentrated here. This is due primarily to the low elevation aspect, plant communities associated with these sites and low accumulations of snow. Critical winter range is considered as that area where deer are forced to subsist during severe winter weather. In this region much of the former deer winter range has been lost to agricultural development and the continuing expansion of subdivisions. This places more dependence on the remaining areas to provide winter habitat for existing mule deer populations. Several cooperative habitat improvement projects have been completed in this area in an attempt to improve winter forage conditions for deer.

Antelope are often observed in the eastern portion of this unit. Presumably, they are part of the Gerber antelope herd. Sagegrouse are present in low densities in the open low sagebrush country.

Golden eagles and other smaller raptors frequent the unit, with some nesting taking place.

Miller Creek Canyon which runs from Gerber Reservoir to Langell Valley is fairly inaccessible and provides quality habitat for many species of birds. Chukars have been released in the Lower Klamath Hills in the fall for controlled hunting with plans for habitat improvement to sustain natural populations.

One of the greatest waterfowl concentrations in North America occurs in the Klamath Basin Valleys. Approximately 80 percent of the waterfowl in the Pacific Flyway pass through and spend months resting and feeding during the spring and fall migrations. Peak fall population is usually in November. Most species of North American waterfowl are present with geese, mallards, and pintails comprising a high percentage of the total. These birds utilize the basin as a resting and feeding stop on their northward migration to nesting areas. Numerous species of waterfowl, however, nest in the basin, the mallard being the most common.

The Bureau of Sport Fisheries and Wildlife presently maintains five National Wildlife Refuges within the Klamath Basin, three of which are in California. In addition, the State of Oregon operates a management area in the basin along the Klamath River in the Miller Island area. They are all managed primarily for the preservation of waterfowl habitat.

1. Specific Areas. (see map 5)

   a. Within the EAR area, specifically the lower Klamath Basin along the Klamath River, is important waterfowl habitat. Over 1,000 Canada geese are produced yearly in this area. Other important nesting species include mallard and redhead ducks.

      In addition to the federal and state refuges in this part of the basin, a private gun club, Tule Smoke Corp. owns 1500 acres of unclaimed marsh. A major California and ring-billed gull rookery is located here.

      This is one of the most important spring-fall migration and feeding areas in the basin. Important geese migrants include snows, cacklers, and white-fronted geese. Non-nesting white pelicans are present at times.

      This portion of the Klamath Basin also serves as a wintering ground for large birds of prey, the Bald eagle being one. They are dependent upon the Klamath River for winter feeding.

      Valley quail, pheasant, and dove are important upland game birds. Pheasant hunting is confined primarily to the area around Klamath Falls, Merrill, and Malin.

      Common fur bearers include muskrat, beaver, otter, nutria, raccoon, mink, and skunk.

Occasional Black-tailed deer use occurs on the fringe of the agricultural lands.

b. The outlying Klamath area, including agricultural lands and settlement areas down to Merrill and Malin receives resident mule deer use on bordering agricultural lands from August to December.

   Waterfowl use here is restricted primarily to migrant use particularly in the spring. The exception to this is Spring and Nuss Lakes, which provide nesting habitat for waterfowl. Limited production by mallards and cinnamon teal takes place in the many canals.

   Fur bearers are limited mainly to muskrats. Winter raptor use also occurs in this area.

c. Poe Valley receives high spring and fall mule deer use along the borders of cultivated fields.

   Upland game use is similar to the Klamath area described previously. Waterfowl use is limited to Lost River with some mallard and Canada goose production occurring.

d. Swan Lake Valley is a natural sump with variable water conditions. It receives heavy resting use by migrant waterfowl during good water years. Some Canada goose nesting and use by sandhill crane takes place.

   Spring-fall deer use on field borders occurs here as in Poe Valley. Valley quail and doves are present. Pheasant are not common.

e. Yonna and Langell Valleys - West Langell Valley receives heavy concentrations of mule deer in the spring and fall. The remainder receives general edge use by deer. Waterfowl use is mainly from spring feeding flights, particularly in Langell Valley. Alkali Lake is the only significant area for waterfowl including Canada goose reproduction and feeding.

   West Langell Valley receives migrant sandhill crane use in the spring. Valley quail and doves are present.

f. The east shore of Upper Klamath Lake serves as a Canada goose feeding and nesting area. It also is a raptor wintering site and receives some mule deer use.

2. Endangered Species.

a. Federal Endangered List.

American Peregrine Falcon - This species has been reported on the National Refuges and possibly exists along the Klamath River Canyon. The species is rare in the area. Little other data is available.

Brown Pelican - This species has been observed occasionally on the Klamath Refuges. It is out of its range and extremely rare in this area.

b. State of Oregon Threatened and Endangered List

Northern Bald Eagle - This species is present and has already been discussed.

Northern Spotted Owl - This species has been observed just outside of the EAR area, but may be present in the area under consideration.

Western Snowy Plover - May be present on refuges or other marsh areas.

Western Spotted Frog - This species may be present according to literature, but presence has not been confirmed.

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(4) Peterson, R.T. 1961. A Field Guide to Western Birds. Houghton Mifflin Co. Boston. 309 p.

(5) Odum, Eugene P., 1959. Fundamentals of Ecology. 2nd edition. W.B. Saunders Co. Philadelphia.

1. Animals (Aquatic)

Fish resources of the Klamath Basin provide excellent recreational opportunity, support an extensive recreation industry, and offer rare or unique species. The basin is especially noted for its rainbow trout populations. The contribution of National Resource Lands to the total fishery of the basin is primarily in the form of impoundments and streams. Important warm water fisheries include the following impoundments: Gerber Reservoir, Willow Valley Reservoir, Bumpheads Reservoir, Malone Dam and Harpold Reservoir. The lower Klamth River, Barnes Valley Creek, and Ben Hall Creek are the primary stream fisheries on B.L.M Lands. Twelve game fish species and twelve non-game fish species that have been identified as occurring within the study area are listed in appendix II. Known fish distribution within the study area is shown on page 46.

According to Dr. Carl Bond, Professor, Fisheries at Oregon State University, "The native fish fauna of the Lost River drainage has already been disrupted by man's activities and many of the species can no longer exist there."

Rare or unique fish life within the study area includes the following:

1. Lost River sucker (Mullet) (Catostomus luxatus) attains a length of up to 36 inches and is legally classed as a game fish. The mullet fishery is unique to the Klamath Basin in Oregon.

2. White sturgeon (Acipenser transnontanus) have been reported in Klamath Lake, but are rare.

3. Shortnose sucker (Chasmistes brevirostris), a rare species appears to maintain a small population in Klamath River below Klamath Falls.

4. Klamath Lake sculpin, (Cottus princeps, found in Klamath Lake.

Invertebrate life of the study area is extensive and diverse. Bottom dwelling or benthic macro-invertebrates were collected from Upper Klamath Lake by the Department of Fish and Wildlife of Oregon State University, in 1964-66. The majority of macro-invertebrates collected from Klamath Lake are distributed throughout aquatic habitat of the study area.

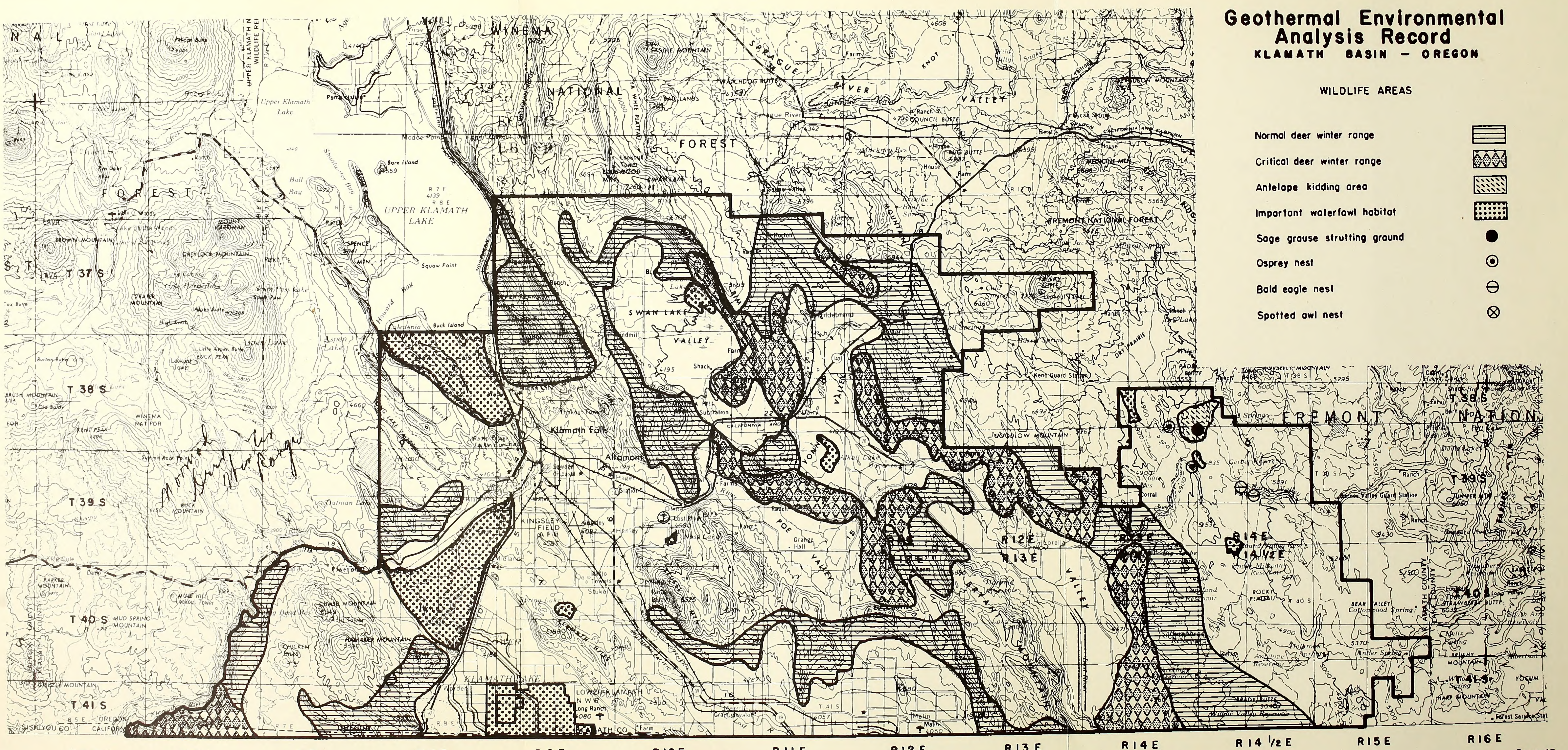
During a study conducted by Oregon State University, from September, 1964, to July, 1965, minute animal life was collected in

FISH DISTRIBUTION WITHIN THE KLAMATH GEOTHERMAL STUDY AREA

LOCATION	Roach	Cottids	Dace	Suckers	Sunfish	Bluegill	Yellow Perch	White Crappie	Black Crappie	Largemouth Base	Brown Bullhead	White Sturgeon	Mullet (Suckers)	Brown Trout	Brook Trout	Rainbow Trout	Coho Salmon
Gerber Reservoir	x			x	x		x	x	x	x	x					x	x
J.C.Boyle Res.	x	x		x	x		x	x	x	x	x	x	x	x		x	
Klamath Lake	x	x	x	x			x				x	x	x	x	x	x	
Lake Ewauna	x	x	x	x	x		x	x	x	x	x		x			x	
Willow Valley Res.	x				x	x	x	x	x	x	x						
Spencer Creek		x	x	x												x	
Klamath River	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	
Lost River	x	x		x	x	x	x	x	x	x	x		x			x	
Miller Creek		x		x	x		x	x	x	x	x					x	
Barnes Valley Creek.		x	x	x												x	
A-Canal	x					x	x	x	x	x	x						
Lost River Canal	x						x	x	x	x	x					x	
North Canal	x							x									

MAP 5

Geothermal Environmental Analysis Record
KLAMATH BASIN — OREGON



Upper Klamath Lake. Samples were taken at various depths and analyzed for species, distribution, and relative abundance.

Although frequency of occurrence varies from that found in Upper Klamath Lake, the majority of species identified are present in lakes, reservoirs, streams, and rivers throughout the study area. (Study data is on file at the Medford B.L.M.)

M. Domestic Livestock

Domestic livestock graze approximately 86 percent of the federal land area under study each year during a May - September season. A total of 84 cattle operations and two sheep operations use the federal land as part of their year long operation. Areas that are not grazed by domestic livestock include the Klamath River Canyon, Miller Creek Canyon, and scattered parcels within the Klamath Forest Estates north of Bonanza. About 20,000 acres receive full season or growing season rest in conjunction with rotation grazing systems.

The majority of the grazing use takes place during May and June. Cattle are then moved to higher elevation or to irrigated pastures. The juniper tablelands supply important early forage to livestock. Forage matures by June, and water supplies are not dependable for later season use. The pine plateaus are mainly grazed during June and July. Tree thickets restrict the forage production and the bulk of the use is made on the openings and the wet areas. Lakebeds and irrigated bottom lands are the most productive for livestock grazing. Livestock use continues until October on some of the allotments. Grazing in the Cascade foothills takes place from June to September. Dense tree cover limits forage production and livestock movement. The small openings, meadows and seeps supply most of the forage in this type.

N. Human Values

1. Landscape Character

The most striking natural landscape feature within the area is the dominance of the uplifted, high ridges and mountains that align in a northwest-southeast direction. The sheer rocky southwesterly ridge faces are generally covered with brush and grasses, and interspersed with talus slopes and rockfalls. The northeastern slopes of the ridges and the gently south sloping tablelands are covered with sagebrush and juniper and cut by draws. The western quarter and the north and eastern edges of the area, where the ridges give way to rolling hills and mountains, are covered with pine forest. Small, shallow lakes and reservoirs are scattered throughout the area.

Except for Upper Klamath Lake and Gerber Reservoir, the lakes and reservoirs add subtle contrasts of color to the dark ridges and mountains. Upper Klamath Lake, although outside the area of analysis, is a dominant part of the scene to the north of Klamath Falls. Gerber Reservoir, in the eastern portion of the area, adds a pleasant contrast to a relatively flat, wooded area.

Two rivers cross the area of analysis. The Klamath River empties into Upper Klamath Lake and flows southwesterly, entering a deep, rugged canyon just west of Keno, Oregon. The turbulent portion of the Klamath River, from John Boyle Dam to Copco Reservoir, has been proposed as a national wild and scenic river. Lost River comes into Oregon from Clear Lake Reservoir in California. Most of Lost River in Oregon has been channeled and modified for irrigation purposes as it made its way through the farm lands in the large valley bottoms. Miller Creek, below Gerber Dam, rumbles through six miles of brush rockchoked canyon. Rock Creek, in the extreme southeast corner of the area, flows into Clear Lake Reservoir. All these landscape features are harmonious and provide a scenic variety.

Visual resources (scenery) are inventoried according to criteria set forth in BLM Manual 6150. The scenery along roads and highways is evaluated using a point system for each scenery component (land form, color, water, and vegetation). The components are given a score of one (if the component is lacking or adds nothing to the scenery) on up to as high as four (if the component adds a lot to the scenery). Two other factors, uniqueness and man made intrusions are also given a score. Uniqueness is scored from one (if it is common) to six (if it is very unique), and man made intrusions are scored from two (if no intrusions exist) to minus four (if the intrusions obliterate the natural scenery).

The scenery components, plus the uniqueness and intrusions, are then summarized and given an A, B, or C rating. These ratings are then compared with vehicular travel along the roads and highways. The areas which are never seen from the highways are classed as U areas (unseen). Those areas which are seldom seen that rated B or C are class IV areas. Those areas which are often seen that rated A or B are class II areas. Other use volumes and scenery ratings vary the class of the area.

Three areas with high scenic value are Topsy Reservor, Gerber Reservoir, and south of Olene Gap (see map 6).

Geothermal Environmental Analysis Record

KLAMATH BASIN – OREGON

Visual Resources

CLASS 2 – High scenic value area.

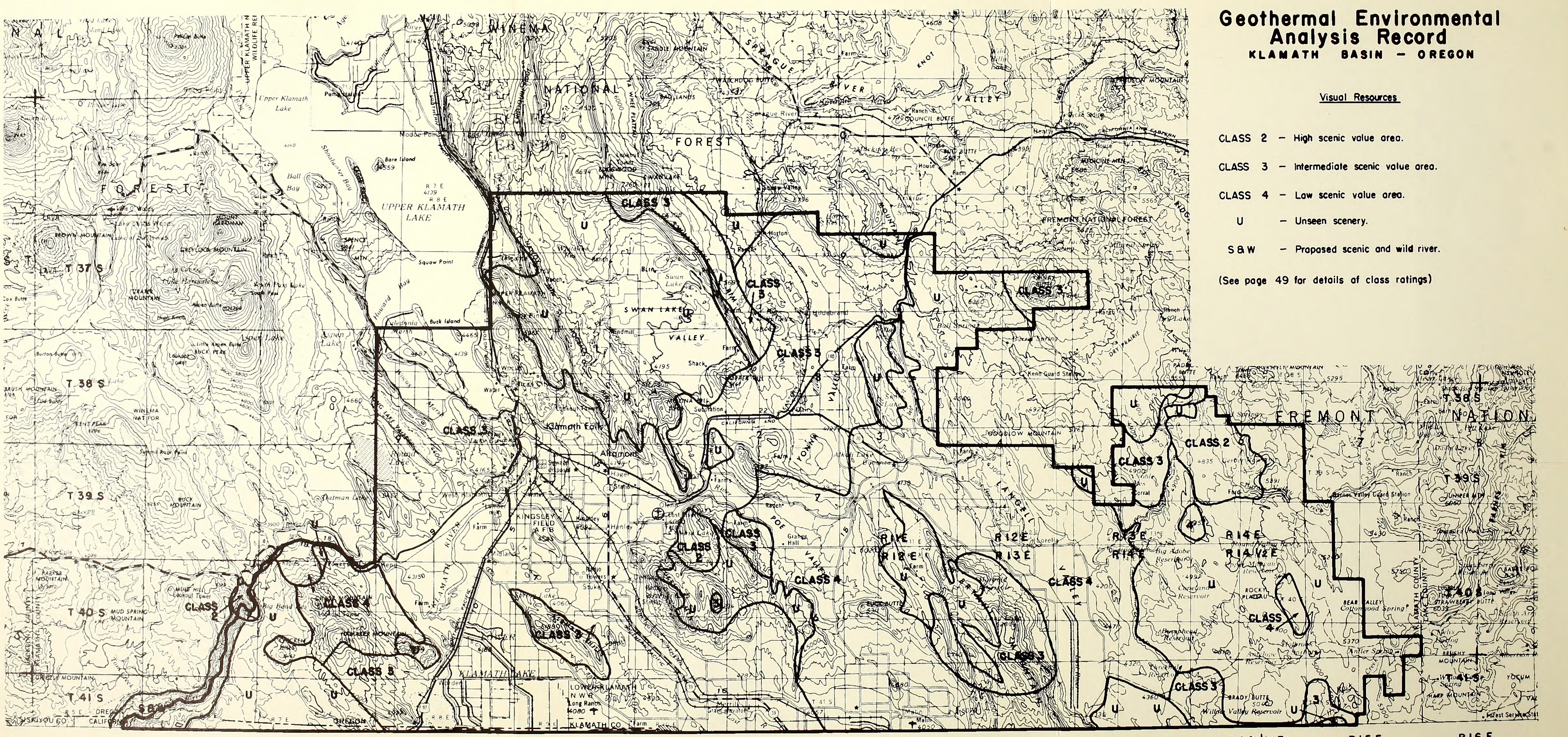
CLASS 3 – Intermediate scenic value area.

CLASS 4 – Low scenic value area.

U – Unseen scenery.

S&W – Proposed scenic and wild river.

(See page 49 for details of class ratings)



2. Man-Made Features

The most prominant man-made feature of the landscape is the metropolitan area of Klamath Falls, Oregon. Smaller communities such as Merrill, Bonanza, Malin, and Keno are situated in the midst of the farming lands. It is farming and ranching that has the most influence on the landscape in the large valley bottoms. The scattered groupings of farm buildings and patchwork of pastures and crops, provide rural setting throughout the valleys. A powerline and gas line dissect the mid-section of the analysis area; however, only the power line follows a raw corridor across the landscape. Roads are numerous throughout the area. Except for the roads and trails that cross the open mountain sides, most roads are a harmonious part of the commercial and agricultural landscape.

O. Socio-Cultural Interests

1. Education-Scientific-Historical

The area covered by this analysis contains several places and objects that merit more than casual interest. These include hotsprings (geological), hot springs biota (ecologic), Applegate Trail and Topsy Grade (historic) and Indian artifacts and occupation sites (archaeologic).

The occurrence of hot springs is common in the west and indicates ground water coming into contact with an underground heat source. To geologists, a hot spring provides certain clues to the subterranean features of the area. Hot springs are usually associated with fault zones, also providing clues to the possibility of natural catastrophic events, such as earthquakes.

There are no hot springs on B.L.M. lands in the study area.

The first whites to see the Klamath Basin were early explorers and trappers. Finan McDonald, a Hudson Bay trapper, passed through the area during the winter of 1825-26. In late 1836, Peter Skeen Ogden crossed the Klamath Basin on his way to the Snake River Country. The region was not visited again until 1843, when John C. Frement was in the area for a short period.

The Applegate Trail and the Topsy Grade Road traverse the Cascade foothills portion of the area (refer to map 7). The Applegate Trail was used by immigrants to Oregon beginning in 1846. The original trail crossed the Klamath

River near Keno and in 1847 the trail was relocated further west between Worden and Keno and crossed the Klamath River one-half mile north of the Topsy Grade Junction. The latter crossing became the chief ford across the Klamath River until 1868 when Browns Ferry was extablished.

Topsy Grade was originally an Indian trail, then used by the Military in the early 1800's and finally became the Pony Express Trail between Henley, California and Fort Klamath in 1863. At that time Henley had the nearest telegraph.

Both historic trails have been researched, traced on the ground and marked by the Klamath County Historical Society.

Early day schools, sawmills and ruins of the early white settlers are present in the Klamath River Canyon.

The first permanent settler in the Klamath region is said to be Wendelin Nuss, a soldier from Fort Klamath. In 1866, he moved a herd of cattle into the Klamath River area. Fort Klamath had been established in 1863 in the lakes region. In 1867, George Nurse, the settler at Fort Klamath, moved to the small river between upper Klamath Lake and Lake Ewauna and established the first buildings of Linkville. The name of the town would be changed to Klamath Falls in 1892. In the 1870's, numerous settlers moved into the area. Trouble soon broke out between the settlers and Modoc Indians, which resulted in the Modoc War in 1872. With the end of the war and removal of the Indians to reservations, cattlemen soon filled the valleys.

The 1880's saw the growth of towns and ranches. In 1882, the present county of Klamath was created, being taken out of the former Lake County.

Farming became an important aspect of the regions development in the 1900's. It was discovered that the lakebed and valley soils were fertile and produced fine crops. Grains and potatoes soon became important crops. One of the first grist mills had been established in 1884. With the development of the Lower Klamath Reclamation Project, and other water control projects, the Klamath Basin became a major agricultural area.

The locations of early day schools, sawmills, grist mills, boat landings and early white settlements are present within the region. In many cases, only the site remains with few, if any, structures. With the exception of the Klamath River, there are no sites or structures on B.L.M. land within the study area. Many of the local small towns and geologic features of the area have been named after early settlers. Stukel Mountain, Merrill, Poe Valley, and Langell Valley are named for some of the early pioneers.

P. Social Welfare

1. Economic Characteristics of the Study Area

The area included in the analysis contains the bulk of Klamath County's 1974 population of 53,400 people and of the county's economic activity. (Approximately 44,000 people reside in metropolitan Klamath Falls. The remaining population is dispersed throughout the county). Population growth in the county has been steady at about 5.4 percent during the last fourteen year period. The overall population density is 8.8 persons per square mile.

Employment in the county is shown in the following table:

		Number Employed	Percentage
1.	Agriculture & Fisheries	1,692	11
2.	Construction	924	5
3.	All Manufacturing	3,761	22
4.	Transportation & Communication	1,316	8
5.	Utilities	273	2
6.	Wholesale Trade	685	4
7.	Retail Trade	3,365	19
8.	Services	2,326	13
9.	Finance, Insurance, Real Estate	510	3
10.	Public Education	1,248	7
11.	Public Administration	1,016	6

Source: 1970 Census of Population

Employment is highest in the manufacturing section followed by high employment levels in the retail trade, service, and agricultural sectors. Manufacturing can thus be considered a major economic activity in the county. The largest group of firms are involved in wood products processing. The service and retail trade sectors also provide a significant amount of employment. The labor force in the study area fluctuates seasonally. This fluctuation results from the area's dependence upon the timber industry. Employment normally peaks in the summer and drops to a low in midwinter.

The number one basic industry in Klamath County is lumber and forest products. Agriculture, which is second in importance, consists of the production and the marketing of potatoes, feed grains, alfalfa, and beef. Tourism and recreation probably rate third in importance.

All forms of services can be found in the county. Most of the services are concentrated in the Klamath Falls area and include several financial institutions, four radio stations, one television station, one daily newspaper, several utility companies, over 60 churches, 3 hospitals, and several schools. Klamath Falls also serves as an important transportation center. The city is served by Air West, Burlington Northern, Inc., Southern Pacific, Greyhound Lines, West Pacific Trailways, and numerous freight companies. Fewer services are available in the smaller communities of Bonanza, Merrill, and Malin, but residents in these areas have ready access to the Klamath Falls Metropolitan area.

Available economic information for the study area suggests that the lumber and agricultural industries are the regions major exporters. The products of the area are sold outside the region and receipts are returned to area residents. Tourism also provides an additional inflow of money into the region.

2. Existing Economic Uses of Geothermal Energy

Since the turn of the century, the residents of Klamath Falls have used the geothermal resource primarily for space heating. Klamath Falls now has approximately 400 hot water wells used for the space heating of approximately 500 structures. When the water heating systems were examined by Lund, Culver, and Svanevik, they found that the total cost items of a hot water heating system consist of the installation cost (drilling, casing, and heating pipes) and the annual operating costs of maintenance (well maintenance, repairs, and pipe replacement), taxes, and electricity for pump motors. The authors found that the 1974 annual operating costs range from $340 to $1100 per year, depending upon well depth. In addition to the annual operating costs, hot water systems also require considerable initial investment. Based upon their analysis, the authors concluded that the cost of hot water well operations in Klamath Falls are expensive for an individual landowner, but costs could be reduced by sharing wells between several landowners. The authors felt that four homes to a well would produce optimum heating efficiency at a minimum cost. At this time, no electrical power is produced in the County by geothermal steam.

3. Local Regulatory Structure

Klamath County is governed by a three member Board of County Commissioners. The county has a Planning Commission. A comprehensive land use plan was prepared for the county in 1972, and a zoning ordinance was prepared and adopted the same year.

With few exceptions, the valley and tableland areas are zoned AF (agricultural forestry) and the Cascade foothill and plateau areas are zoned as forestry zones. These zones are intended to provide for agricultural and forestry uses. In addition to these zones, the county has placed the area's critical deer winter ranges into a special zone in the tablelands of Windy Ridge and east of Langell Valley. These special zones are combined with other zones, and identify critical deer winter range areas. The county has also placed special use zones on the communication sites scattered throughout the study area.

Geothermal steam was briefly mentioned in the county's land use plan, however, there is no mention made of geothermal steam in the zoning ordinance itself. The county has a special zone, SP-16 (Planned Unit Development) for dealing with activities such as geothermal development. Under the zoning ordinance, a geothermal steam developer must apply to the county for a SP-16 zone change and a conditional use permit.

Where the end product of geothermal steam development is used is an important consideration when evaluating possible impacts of geothermal development. If the electrical power is used near the plant site, the region could conceivably experience considerable economic growth in the future. If the power is transported out of the study area, few impacts beyond the development phase will be evident.

These examples illustrate extreme situations and any discussion of possible impacts is speculative at this time. In essence, development cannot occur without some strain on communities and on the people who reside in these communities. The level of impacts will range from moderate to severe up to and through the development phase. When the field is developed and producing, impacts associated with growth should diminish and demand for social services should stabilize during development. This procedure gives local government an opportunity to examine and evaluate each phase of future geothermal development. If problems occur, the county can take remedial action as necessary under this procedure.

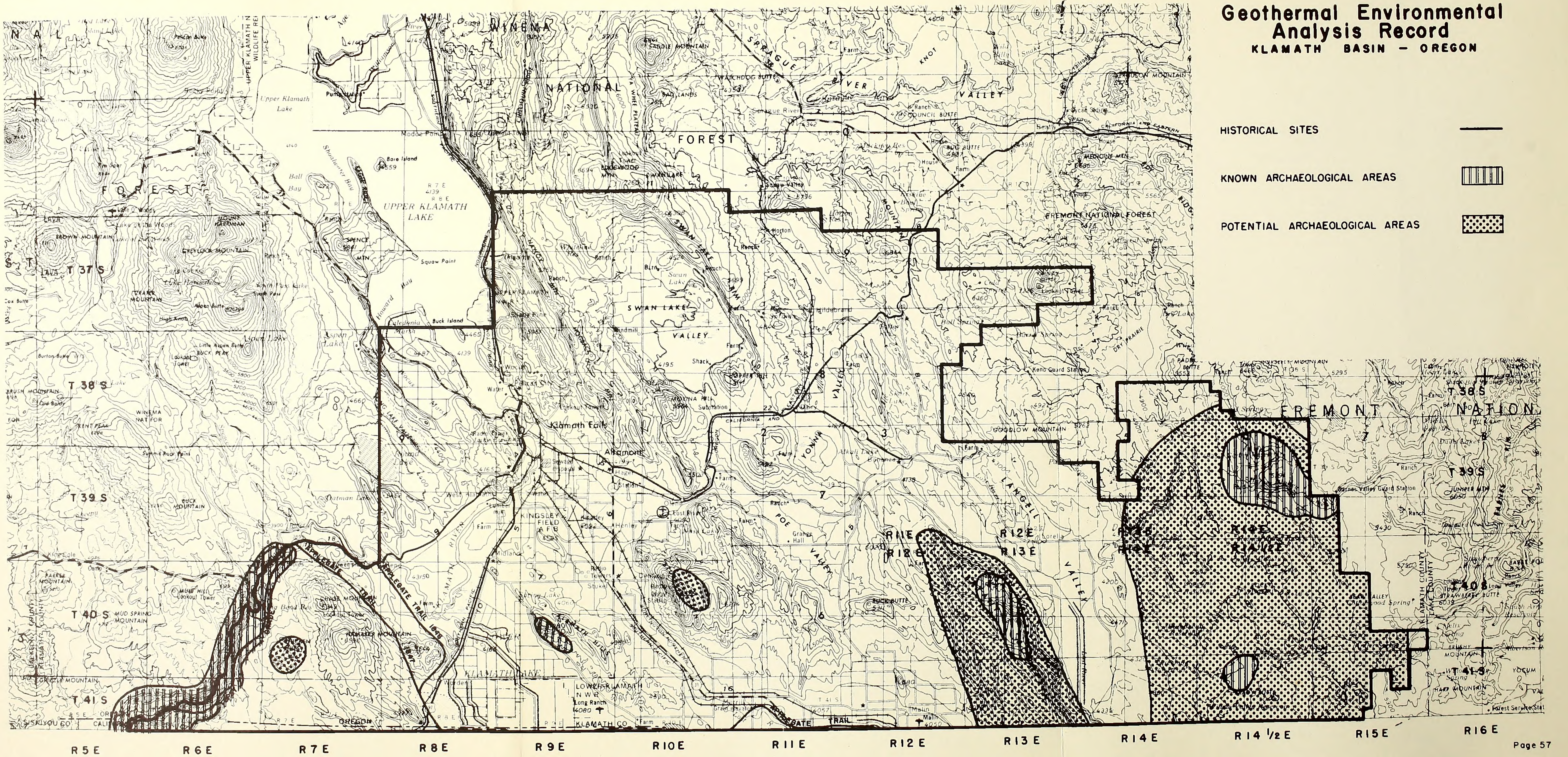
Sources

1. Bureau of Business Research, Oregon Economic Statistics, 1974, University of Oregon, Eugene.

2. Lund, John W., G. Gene Culver, and Larson S. Svanevik, Utilization of Geothermal Energy in Klamath Falls, Paper Presented at the International Conference on Geothermal Energy for Industrial, Agricultural, and Commercial-Residential Use.

Geothermal Environmental Analysis Record

KLAMATH BASIN – OREGON



HISTORICAL SITES —

KNOWN ARCHAEOLOGICAL AREAS ▥

POTENTIAL ARCHAEOLOGICAL AREAS ▨

Q. Archaeology

The Klamath Basin contains many areas of archaeological value. For discussion purposes the area is divided into four physiographic zones. While archaeological research has been performed in only two of these zones, predictions of archaeological values can be made for the area based on known archaeological sites, previous archaeological research, disclosure of site locations by informants, and information regarding sites contained in ethnographic reports that describe the historic cultures of an area.

The Klamath Basin was inhabited historically by two distinct cultures, the Klamath and Modoc Indians, both of which are members of the Sahaptin language group. Reconstruction of their life ways through ethnographic accounts reveals unique adaptations to the lake environment of the Klamath Basin. Reconstruction of the prehistoric period through archaeological research shows continuous occupation of the Basin over a 10,000 year period.

A brief summary of the Klamath and Modoc cultures and area prehistory is available at the Lakeview District Office.

Archaeological site types found in the area include village sites, temporary occupation sites, hunting sites, middens (garbage dumps), cremation sites, religious sites, occupied shelters and caves, and a few petroglyph/pictograph sites. Site locations are generally indicated by lithic (stone) debris, projectile points, milling tools, rock piles and structures, house pit depressions and middens. The principal site locations are on the border of marshes, along sheltered lakeshores, near springs, and along river terraces.

The KGRA area was examined for significant cultural resources. During the survey, no significant cultural resources were located. This was felt to be due to a combination of factors. The slope of the terrain was often 45° or more with large amounts of barren rock and little vegetal ground cover. There were no permanent springs or streams within the area surveyed. However, valley lowlands were often in close proximity. The valleys would have supplied abundant water, shelter, and food resources to native populations. Sites have been located within these more favorable locations. This is the pattern that has been established through previous archaeological research and information contained in ethnographic accounts of native populations of the area.

A complete inventory will be made of all future lease areas before any geothermal development activity takes place.

In addition to a survey of the KGRA, some locations within the EAR area were examined for sites. Many archaeological sites have been reported within the EAR area by the Klamath County Museum. Information on location, site type, and condition is kept on file by the museum. None of these reported sites are on public lands within the KGRA.

The Oregon Archaeological Survey files at the Museum of Natural History, University of Oregon, lists five sites for the EAR area. None of these sites are within the current KGRA. The National Register of Historic places lists two sites within the EAR area, the Baldwin Hotel in Klamath Falls and the Lower Klamath National Wildlife Refuge.

Ethnographic reports on the histroic'Klamath and Modoc cultures also contain references to numerous site locations, but do not give specific information on these locations.

The State Historic Preservation Officer has not conducted surveys for cultural resources in this area. He has requested copies of our survey information for evaluation.

The focal point of aboriginal activity within the pine plateau areas was around the numerous springs, small streams and small basin lakes.

The sites which have been identified in these areas are hunting and gathering camps of temporary seasonal occupation. The use of these occupation sites is indicated by the location, size and artifact inventory. The observed projectile points indicate a fairly recent time period, but stratified occupation debris appears present at some sites and excavation might reveal earlier site use.

The Bryant Mountain and Gerber Reservoir areas appear to contain numerous sites of archaeological value. These areas are not within the area of lease interest. If these areas are to be leased at some future date, a complete cultural resource inventory will be made to determine if significant cultural resources are present.

Investigations of the Cascade foothills are incomplete but it is likely that sites similar to those found in the pine plateau areas are located within this zone. Ethnographic reports indicate use of the area for hunting and gathering. This land use pattern is likely to have been similar in the prehistoric period.

The Klamath River Canyon has had some intensive study. Five sites along the river have been identified by the Klamath County Museum. The Klamath River was investigated by Dr. Luther Cressman of the University of Oregon in 1960-61. Twelve sites were identified on the river terraces. Site types were winter and summer villages, temporary occupation sites and middens. Test excavations revealed that some sites were used repeatedly over a 6,000 year period. The area is transitional between the Klamath Culture area and California Culture area as it shows culture traits from both areas.

The possibility remains of more well stratified occupation sites being located along the Klamath River. Although a distinct form of local adaptation can be seen, the area is important in determining prehistoric contacts between culture areas.

Areas of juniper tableland are widely distributed within the study area. Archaeological investigation of these areas is outside of the KGRA. Archaeological values might be found near water resources. Ethnographic reports indicate use of these areas, especially east of Langell Valley, by the historic cultures of the area.

The focal point of aboriginal activity would be around springs and streams. The principal site type would be small occupation camps used as bases for hunting and gathering activities.

Large valleys and lakebeds are found throughout the study area. The principal areas of valley and lakebed are the lower Klamath Lake, Swan Lake Valley, Poe Valley, Langell Valley, and the southern portion of the upper Klamath Lake.

The associated streams, rivers, springs, and lake basins within these valleys were the focal point of aboriginal activity during both historic and prehistoric periods.

Archaeological research was first performed in these areas by Dr. Luther Cressman of the University of Oregon. He reported the finding of lithic and worked bone cultural materials in apparent association with extinct pliestocene fauna in clay deposits in lower Klamath Lake. Further investigation of the Klamath Basin was again carried out by the University of Oregon, under the direction of Dr. Cressman, from 1947-1951. The center of investigation for this project was the Upper Klamath Lake area. Evidence was found of a continuous occupation of the Klamath Basin covering a 10,000 year period. The historic Klamath culture is seen as the culmination of this long period of occupation.

Site types located include villages, cremation sites, fishing sites, middens, and temporary occupation sites. The majority of the sites are on lakeshores, marsh areas, springs, and rivers.

In addition to those sites reported by Dr. Cressman, some 35 sites were reported for these areas by the Klamath County Museum. There is also numerous references to site locations contained in ethnographic reports.

The Upper Klamath Lake is also one of the few areas in the Klamath Basin where petroglyphs are found. Although none are currently known within the EAR portion of the lake.

Artifact collectors have destroyed many sites within these areas. Cremation sites are reported to be nearly completely destroyed.

The major portions of the valleys and lakebeds are in private ownership and much of the area is now farmland. Farmers report frequent findings of projectile points, milling tools and some burials as they work the land. The lower Klamath Lake has been placed into farmland by a Bureau of Reclamation project. The present towns of Olene, Lorella, and Klamath Falls have been built on or near old village sites.

Construction, farming and artifact collectors have destroyed many of the sites within the valleys and lakes areas. However, it is likely that buried stratified cultural material will be found in the future. No sites of National Register quality are known to be on federal lands within the valleys.

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R. Attitudes and Expections

Klamath Basin residents have been exposed to practical uses of geothermal energy for many years. Several homes, churches, public buildings, commercial locations, Oregon Institute of Technology, public places (including the County Museum and the City swimming pool) are all heated by geothermal energy.

Oregon Institute of Technology is a lead research agency in geothermal uses and hosted an International Conference on geothermal energy in October 1974.

During the past two years, stories about geothermal energy have had prominant coverage by the Klamath Falls daily newspaper.

In addition, private companies have leased the bulk of the private lands around Klamath Falls and surrounding valleys for geothermal exploration.

Expectations run from very high to very low. Some speculate that the heat source will not be large enough or suitable for power production but well suited for space heating and agricultural uses.

Some people that heat homes, and have hot water systems from geothermal wells fear that added exploration and development could reduce their existing heat source.

Most residents seem to favor leasing of federal lands for geothermal exploration. (See Intensity of Public Interest Section for comments on the lease program.)

S. Ecological Interrelationships

Plant Succession

The successional process within the designated area is complex and diversified due to the variety of sites and corresponding plant communities. It would be unrealistic to attempt to describe in detail the successional stages and changes in a document such as this.

The following basic statements are intended to give merely a broad overview of the more prominent successional patterns that may be related to this proposed action.

Timber sites are restricted to the high areas with sufficient moisture and soils to support the trees. The greatest impact on the successional direction of these sites is complete timber removal by man or nature. If left unaltered the site will go through a series of seral stages, beginning with annual forbs and grass, then gradually shifting to perennial grass and shrubs. The shrubs will dominate until such time as the conifers become established and gradually force out the lesser species, finally resulting in a coniferous forest climax. This process takes a long time and is dependent upon many variables. One of the most important variables is the distance from a seed source.

Under present forest management, this process is often accelerated by such actions as tree planting, bypassing the intermediate stages and returning the site to a forest type again.

The juniper types represent somewhat a different sequence. The older juniper trees are generally found on rocky ridges with relatively deep soil between the rocks and in small swales. Heavy grazing over a prolonged period of time, periods of drought, and suppression of natural fires have greatly extended the area covered by this species. Juniper is adapted to a wide range of sites, and given adequate moisture invades rapidly as perennial grasses and shrubs lose vigor. Once established, this species generally maintains dominance of a site. Perennial grasses and shrubs are forced out adn tree interspaces support various annual forbs and grasses. The degree of plant variety in juniper types decreases with the severity of the site.

The sagebrush types can be broken into two general categories, big sagebrush and low sagebrush. Low sage generally occurs on the shallow stony sites of the well drained upland plateaus.

Lower seral stages are characterized by the presence of sandberg bluegrass, and a great variety of annuals. This may be the result of past abuse by grazing or simply severe site conditions.

Big sagebrush is best adapted to the deeper well drained soils. It is often found in association with bitterbrush and rabbitbrush. Due to the combination of factors or events mentioned previously, many of the preferred browse and grass species have declined. This has resulted in an increase in sagebrush and/or rabbitbrush, depending on the site. On many deer winter ranges, sagebrush is a critical browse. This grazing use, plus other land disturbances has led to an increase in gray rabbitbrush and cheatgrass. These changes are all inter-related and do not follow the natural scheme of succession.

T. Food and Community Relationships

Within the broad area involved there are numerous food relationships between plants and animals and among animals themselves. All, however, are dependent initially upon the production of food materials by green plants. The existing vegetation and associated climate dictates what animal species will inhabit an area.

Following are examples of some of the basic relationships that exist within the area.

Deer are dependent upon specific seasonal use areas to provide yearlong forage, water, and cover. Forage requirements and availability change with the season. A forage deficiency on a particular seasonal range (intermediate, summer or winter) will limit populations even though surplus forage is available on other seasonal use areas. Winter ranges within the basin are limited in geographical area. These ranges are the only sites with suitable characteristics for providing winter deer habitat. This increases the importance of these areas in fulfilling a critical segment of the life cycle for existing deer populations. Although they are of equal importance, the other seasonal use sites cover a much larger geographical area.

Predatory animals such as coyotes, bobcats, badgers, golden eagles, hawks, and owls prey primarily upon rodents, rabbits, and other small animals. Rodent and rabbit populations are somewhat cyclic and governed to a large extent by production of plant material (green forage and seeds) for food. Food production is related to site capability and climatic conditions on a given area for a given year. During periods of low rodent and rabbit populations, many predators will shift to a degree to other prey species that are available (birds, deer, sheep, calves, etc).

Aquatic oriented predators, the osprey for example, have a different situation. The food chain for this species is basically as follows. It begins with water capable of supporting phytoplankton, followed by zooplankton which feed on the minute plant life. These tiny animals are in turn eaten by larger invertebrates and small fish. Small fish are eaten by larger fish, and these fish taken by the asprey. Any break in this sequence would have an impact on all of the organisms of a higher trophic level.

Waterfowl production is dependent upon the maintenance of quality aquatic habitat. This includes production of aquatic plants and animals for food and cover, and maintenance of water levels in the lakes and marshes in the basin. Any change in these components will be reflected in waterfowl use and production.

III. Analysis of Proposed Action and Alternatives

A. Non Living Components

Geology

Exploration and development will have a very minor impact upon geology, amounting simply to the drill holes left in the ground after drilling. An additional impact possible on the Cascade foothills is that of landslides caused by road and drill pad construction on steep slopes.

Several components of the geology will be impacted during the operation stage by both waste disposal and production. The components are subsidence, seismicity, rock temperatures, and hot springs.

Subsidence may occur in the valleys as the geothermal fluids are removed from the ground during production. The probability of subsidence occuring in this area is very low because of the rock types in the area.

Seismicity may be affected by both waste disposal (re-injection of geothermal fluids) and production (removal of geothermal fluids). Removal of the geothermal fluids might have the probable effect of decreasing the number, and increasing the severity of local earthquakes. Reinjection of the geothermal fluids would have the probable effect of increasing the number and decreasing the severity of local earthquakes.

The rock temperatures will gradually be reduced by the production of geothermal power. The temperature reduction rate is unknown. The temperature reduction rate may be so slow that it is immeasureable, or it may be very fast. The result of the rock temperature dropping too fast would be to terminate the use by the geothermal developer prematurely. This may also reduce local hot spring and hot well temperatures.

Hot springs may be affected by production (removal of geothermal fluids) and reinjection (replacing geothermal fluids). Existing hot springs or wells may become larger or smaller, new hot springs may start, or old hot springs or wells may disappear.

Air

Particulate matter, (dust) will be dispersed during all of the stages of implementation. Concentrations on the pine plateaus, juniper tablelands, and Cascade foothills are expected to be higher than the state air quality standards. Concentrations in the valleys are not expected to exceed state air quality standards. The highest concentrations will probably occur during the summer when the soils are dryest.

The only significant contribution of noxious gases would be from drilling operations. The noxious gas most likely encountered would be hydrogen sulfide of concentrations similar to that found in hot springs. This concentration may be very near the state air quality standards and may exceed the standard during production testing in the development stage, and during maintenance, waste disposal, and production in the operational stage. Concentrations may be increased during winter months by inversion layers within the valleys but probably not to toxic levels. The toxic effect of hydrogen sulfide is not cumulative. The impact on an individual in the area would be a rotten egg odor.

Temperature will be impacted by production and possibly by waste disposal. The impact would be to increase the air temeprature by 1 to 2 degrees F in the immediate vicinity.

Air movement patterns may be impacted by production and possibly by waste disposal. How the air movement patterns will be impacted by the venting of large quantities of steam is unknown.

Non-Ionizing Radiation

Non-ionizing radiation will be impacted by the production of electricity. The impact will be interference with radio transmission and reception by the 60 cycle frequency of the generators and transmission lines. This impact will be localized around the geothermal power plant and along the transmission lines.

Land Use

Several exploratory activities will have a minor impact on land use while other exploration techniques may permanently alter land use. Obviously, airborne exploration will not impact existing land use. However, off-road vehicular travel and additional road and trail construction will open areas previously closed to motorized travel. Additional physical access can result in more recreational use of previously inaccessible areas, thus altering existing land use patterns. The use of numerous roads for exploratory purposes will not negatively impact existing land use. In general, the exploration is for a short duration, and will not have a long term impact.

Road and trail construction during the exploratory stage could temporarily disrupt existing land use by destroying vegetation, compacting the soil and adding to erosion. Noise from seismic blasting and shallow hole drilling will be a nuisance if done near population centers or farmsteads. Drilling activity may cause temporary scenic disturbance to the public lands on the west side of Stukel Mountain, south of Olene and north of Pine Grove.

The development stage requires several wells and possibly the construction of one or more electric power generation plants. In general, 16 to 20 producing wells are required per power plant. Generating plants are centrally located to minimize pipeline length. Power plant spacing is about one plant per 640 acres throughout a producing field. If a field is developed, existing land uses on 640 acres per power plant will be interrupted and the primary use will be changed to electric generation. This impact will be greater in irrigated cropland and urban areas because high value land is removed from production or use. Noise from drilling and construction will last for long periods of time. The noise levels of muffled wells have been described as slightly less than that of an unmuffled diesel truck. Decibel readings for machines with mufflers read from 70 to 125 decibels. Continued exposure to anything over 90 decibels (decibels measure loudness not pitch of sound) can cause permanent ear damage. These loud noise levels will definitely be annoying to adjoining land users.

The construction of power transmission lines will further impact land use. This facility will impact areas completely removed from the immediate site. If crossing cropland, cultivation and irrigation will become difficult. Visual impacts may be considerable, depending upon line location and line size. By the time the operation phase is reached, most of the major land use impacts have occurred. Other operations such as drilling additional wells may occur during this phase.

Water and Soil

Surface disturbance will effect each specific physiographic unit differently, depending on the extent and kind of disturbance. Valley bottoms are generally flat with little to no relief in topography. Exploration and development in the dry portions should have minimal effect on soil erosion and sedimentation of surface waters. Disturbance in the wet areas by seismic surveys could increase sedimentatation of surface water through vehicle activity and drill site preparation. Exploration sites in these wet areas would require a drill pad - this may increase sedimentation. Quality of surface water in the valley bottoms is presently low and may not be significantly impacted.

Topography on the juniper tablelands and pine plateaus have slopes ranging from 0% to greater than 60%. The relationship between slope, soil types, and vegetative cover is very important to soil stabilization.

Soils on juniper types are very susceptilbe to erosion if the vegetative cover is removed or disturbed. Erosion potential exists even from a minimum disturbance such as a drill site. Road or building construction on these soils would increase erosion and runoff significantly and may cause offsite damage to water resources.

Soils on the pine types are more stable. Road construction or individual drill sites would not increase erosion or sediment load significantly.

However, if a geothermal generating development was completed in either physiographic unit, the combination of activity involved may have a high impact. There may be enough soil disturbance and soil compaction associated with its development that ground water recharge could be reduced. Stream or spring flow may or may not be impacted.

Within these physiographic units several upland meadows exist, exploration or development in or directly above these meadows would be damaging. If a shallow water table is present, any surface disturbance would increase runoff and erosion. An increase in erosion could lower the water table and result in decreased discharge from the spring and/or streams fed by these meadows.

In all stages of implementation ground water may be impacted. Blowouts during exploratory drilling or during production stages may occur, introducing to the ground water supply toxic or undesirable substances. Accidental spillage from waste ponds may occur affecting both the shallow water tables and the regional water table. After rehabilitation of a site, seepage from waste ponds could have an effect on both surface and ground water for an indefinite period.

What effects geothermal development will have on the hydrologic cycle is unknown.

Vehicle travel, associated with all stages of implementation, during wet soil conditions will adversely effect all areas. Travel during this period will cause increased soil compaction, disturb surface vegetation and damage roads. In some cases gullies may result.

B. Living Components

Impacts on living components of the environment from an action such as this are difficult to accurately predict. Because of the great number of unknowns, the relative importance of potential impacts depends on several variables. Definite site location, degree of development, and timing of developments are paramount among these. The following impacts will be limited to general problems or conditions that could occur within each stage of implementation.

Wildlife

Potential adverse impacts to wildlife during normal exploration activities are expected to be minor and temporary. Increased activity and disturbance in waterfowl breeding areas, deer winter ranges, raptor nesting sites, or other critical animal use areas may prove detrimental to the affected species. However, this will be temporary and lasting impacts should not be significant. Greatest concern is the increased access resulting from road and trail construction in all units but the valley bottoms.

Future use of these roads by the public could lead to increased harassment of animals during critical periods of their life cycle.

If deep well exploration takes place in aquatic types (lower Klamath Basin, etc.) the disturbance will be greater and result in an expected loss of 6-8 areas of habitat for each well site.

The increased disturbance, activity and noise levels associated with development and operation could prove detrimental to many species, especially during the breeding season or in critical wintering areas. The full significance of this is not known at present because many species adapt to changing conditions and increased human activity, while others tolerate little change. Raptors for example, have abandoned nests because of the presence of man. The impact may be temporary or permanent depending upon the tolerance level of the individual species.

In the immediate area being developed, forage and cover would be removed, resulting in localized loss of habitat for terrestrial species. This could result in a moderate amount of acreage being disturbed. It may prove to be a lasting adverse impact if the site is in a sagegrouse strutting ground, antelope kidding ground, critical deer winter range, raptor nesting sites, or other critical animal use areas. The severity of the impact is dependent upon the number of sites, amount, and location of land involved. For example, one development within a deer winter range may be tolerable, but five or six in the same area would have a high impact.

Impacts to aquatic species of plants and animals would be restricted primarily to the valley bottoms, Gerber Reservoir, and other water bodies. If the development encroaches into the aquatic type there will be a loss of habitat. Again the significance of this is dependent upon the cumulative effect of development over the entire lake, marsh, or feeding area. Disposal or accidental discharge of waste effluents into lakes or drainages could prove detrimental to this resource. Changing the chemical or thermal properties of existing water could alter the aquatic environment. Significant changes or reduction in aquatic vegetation would be reflected in reduced waterfowl use and production. (Lands within the National Wildlife Refuge are not open to geothermalleasing.)

If surplus water is of acceptable quality, waterfowl and other aquatic habitat could be enhanced. Should waste water associated with production prove to be toxic, it would present a hazard to animal and plant life. However, if water is of acceptable quality it would be beneficial.

Construction of transmission lines will attract raptors. If improperly designed, electrocution may result.

Critical areas are delineated on map 5.

The endangered and threatened species, with the exception of the Northern Bald Eagle, are not usually found in the EAR area. The actual impacts of geothermal development on their welfare is unknown; however, direct impacts can be avoided by not leasing within nesting sites.

The close-out operations should prove beneficial to most animals. Human activity, disturbance, and high noise levels associated with producing wells will be removed. Many of the disturbed sites and roads can be reseeded and the latter put to rest, thereby partially replacing lost forage and cover and reducing access.

Livestock

Drill sites, steam plant construction and off-road vehicle use may disturb livestock in areas where animals normally concentrate, such as water sources, meadows, and grass seeding. Emission of waste and sumps for mud and waste water may be hazardous to livestock. Pipelines and equipment may interfere with livestock movement. Loss of forage production will take place if disturbed areas are not reseeded. If development occurred on one of the many small areas leased to grazing, a plant site could eliminate the entire lease.

Terrestrial Vegetation

All stages of geothermal energy production will have some degree of impact on the native vegetation.

Exploration work could result in crushing or removing vegetation from as much as 40 acres per lease area. The real impact would vary, depending on the site involved. In the mixed conifer physiographic unit, for example, this could mean the loss of 40 acres of productive timber lands. Destruction of valuable browse and cover would take place in the juniper tablelands.

The impacts of development and operation would be similar to those of exploration but of greater magnitude. Up to 360 acres per lease site could be cleared of vegetation. Impact to vegetation beyond the cleared areas could result if waste seepage of spills occurred.

Closeout of a geothermal operation could have both adverse and beneficial impacts to vegetation. Additional plant damage could occur. Vegetation could be restored to the sites, but the success of rehabilitation measures would be lower in the tablelands and plateaus than in the valley or foothills.

c. Human Values

Archaeological

Positive impacts may result from an archaeological survey and salvage performed on previously undiscovered areas. The increase in archaeological knowledge gained may outweigh the disturbance of site areas that are at present unprotected from vandalism. This would be true near accessible sites.

Negative impacts during geothermal exploration and development will be both direct and indirect.

Direct impacts will result from surface disturbances during road construction, testing wells, placement of steam power plants, and offices. Disturbances of site surfaces and subsurfaces will destroy the stratigraphy of sites. Surface sites are especially vulnerable as merely clearing and leveling an area may completely remove the site. During excavations for construction purposes, unknown sites may be encoutered. If care is not taken to insure that lease stipulations are followed, the site could be completely destroyed. Direct impact could also result from work crews hunting for artifacts or intentionally destroying sites.

Indirect impacts will occur during and after geothermal development. The effects would be cumulative and could eventually result in total destruction of sites. New or improved roads could improve access to sites. The tourist attraction of large work crews and good access roads may increase artifact collecting. This is one of the major causes of site destruction in the United States. Only areas not readily accessible to the public have escaped heavy damage.

The number of new sites found and information gained through salvage in implementation of lease stipulations may be outweighed by loss through direct and indirect impacts. The maximum data should be recovered from every site that is disturbed. Once it is destroyed, it cannot be reclaimed at a later date.

The significance of geothermal leasing on known archaeological sites will vary with the significance of those sites. Of the four physiographic zones, only the valley and lakebed zone and Cascade foothills zone have had archaeological research performed within the areas. The number of sites in the Klamath River Canyon is significant enough to warrant nomination to the National Register of Historic Places.

The valley and lakebed zone is nearly all private lands, so the effect of leasing on government lands will be minimal.

Additional investigation of the pine plateaus, juniper tablelands, and Cascade foothills would aid in determining their value. They may contain sites of National Register quality. All of the areas have been open to public access and some site destruction by artifact collectors has already taken place. Leasing may increase the trend unless mitigating measures are taken.

Landscape Character & Aesthetics

All phases of geothermal development will have impacts on the landscape. During the exploration and development phases new roads and trails will add lines of contrast to all landscape features. New roads and trails will be most harmonious in the irrigated valleys and most inharmonious on open slopes on the plateau and foothills. The higher the standard of the road or trail, the longer the impact on the landscape will last. The lowest standard of road or trail will have the best chance of revegetating and eliminating contrasting scars. Topography in the plateau and foothills will somewhat break up the contrasting road scars by screening portions behind hills or vegetation. Drill rigs, wells, plants, pipelines, and transmission lines will become long-term intrusions upon natural landscape features in these areas. These structures and facilities will have lower visual impacts in the valleys where similar structures exist. The close out phase of geothermal development will remove inharmonious features from all landscape regions and rehabilitation procedures will reduce contrasts of form, line, color, and texture qualities of the landscape.

Odors of various gases may permeate the air during the exploration, development and operations phases and have an impact on the experiences and pleasures of both the residents and visitors to the area. The impact of the gases will be dependent on the amount and density of the gas and its location in relation to populations.

The noise may also have an impact on the experiences and pleasures of both residents and visitors.

Education/Scientific Resources

During geothermal exploration, surface disturbance will be minor, but beneficial impacts may be high, owing to the additional knowledge of the geology gained through geologic mapping, geophysical exploration, and geochemical surveys.

During development, road construction and drill site location could affect the Applegate Trail and Topsy Grade by isolating, fragmenting, and destroying portions. Increased access would promote vandalism of historic sites.

Since these routes were important to the history of the west, the adverse impact of destruction would be quite significant on the quality of the cultural environment of the region, but perhaps not as significant on a National scale.

It is also possible that geothermal operations may increase the flow at hot springs. After the 1968 earthquake, Cox Hot Springs in Warner Valley increased its flow, however, other hot springs and geysers in this area did not change. If flow rates do increase because of geothermal development, it is likely that the change would be beneficial.

Social Values

Several general observations can be made concerning probable economic impacts. Nearby communities will benefit in the form of increased expenditures from workers employed during geothermal development, and in the form of an increased tax base. These same communities will be required to provide additional services for employees. The magnitude of these impacts will obviously vary, depending upon the type of developments and the number of persons involved.

Exploration crews have been testing in the Klamath Basin during 1975. Seminars conducted by O.I.T. and the possibility of geothermal energy for agriculture has brought interested people into the area. These impacts are subtle and will be felt regardless if BLM lands are leased. A major field, plus power generation, would intensify the impacts.

The probable impacts of geothermal development on social welfare are difficult to assess at this time. Exploration drilling will probably require two rigs for a one to two year period and at least 40 to 60 people will be needed during this period. The development phase would probably occur over a 2 to 10 year period. Additional drilling crews and construction workers will be required for development. The numbers of workers required during development is a direct function of the number of plants eventually built, the number of wells eventually drilled, and the amount of transmission facilities required.

The impacts on social welfare can best be described by explaining different situations. For example, a large geothermal field is developed near a small community such as Bonanza, the impacts of exploration and developments will be big. Fast growth will strain existing housing and place excessive burdens on other community services such as schools. If a small geothermal field is developed near Klamath Falls, the impacts of exploration and development will be minor and generally positive in nature. The additional people required for the development could be incorporated into the metropolitan area with little strain on community services.

D. Ecological Interrelationships

Plant succession will be altered on all disturbed sites. Little significant impact is anticipated for most plant communities because impacts will be very localized.

Successional changes will be left to natural processes. Most of the disturbed sites will revegetate, although species may differ from the original flora. Introduced species resulting from rehabilitation will be present on those sites where they are adapted. Other sites may be dominated, at least temporarily, by annual and perennial species able to survive the altered environment. Regeneration of the vegetation on commercial timber sites will require many years to regain its original status.

E. Food and Community Relationships

Food relationships will be altered on localized areas by loss of vegetation and subsequent animal production. The loss of use areas, critical for a species to complete its life cycle, would obviously be detrimental to that species. For example, the significance of destruction or encroachment upon a large segment of critical deer winter range could depend upon the exact location and amount of land involved.

Most impacts relating to the development and operational stages have been discussed previously, increased activity, noise, pollution of existing water, etc. All of these factors may alter animal habitat relationships either directly or indirectly. For example, accidental pollution of the water in Gerber Reservoir would alter the aquatic ecosystem, the basic life forms and water characteristics necessary to sustain fish would not be present. Without fish life, the osprey would be unable to remain in the area. This example is included only to illustrate one of the many indirect impacts that could occur.

F. Alternatives and Environmental Impacts of the Alternatives

No Leasing

One alternative is to decline to lease the land. This alternative would involve an administrative decision by the B.L.M. not to lease for geothermal resource development any of the federal land within the Klamath Basin geothermal area. The environmental impacts of the alternative are as follows:

1. A decision not to lease would be contrary to the intent of the Geothermal Steam Act and the attitudes and expectations of the majority of interested Oregonians who feel that the B.L.M. should contribute toward the development of this states widely publicized geothermal resources. There are national expectations which have been reinforced by the recent "energy crisis" and the Federal Government's

declared intent to encourage development of new energy sources.

2. A decision not to lease could encourage energy producers to turn to other energy sources to meet the nations growing demands. Most of these alternative energy sources have larger adverse impacts upon the total environment than geothermal resources.

3. A decision not to lease could seriously hamper efficient development of the resource on adjacent private land that is presently being leased.

4. A decision not to lease would conserve the geothermal resources in the area for use by future generations.

Alternative to the Proposed Action

Leasing Land With Low Resource Conflict

This alternative would permit leasing of only a portion of the land. Lands will be open to leasing if geothermal development would not significantly impact the other resources, or where mitigating measures would adequately protect the other resources. Two of the resources which will be in direct conflict with geothermal development and may not be able to be mitigated adequately are wildlife habitat areas and scenic areas.

Wildlife habitats that have unmitigable conflicts are raptor nesting areas, waterfowl production areas, and other aquatic habitat areas. Scenic areas which present unmitigable conflicts are areas of high recreation use or unique scenic qualities.

For those lands which may have high resource values, refer to map 8.

IV. Possible Mitigating or Enhancing Measures

Potential known or anticipated environmental problems have been identified in this analysis. Many of the impacts can be mitigated through enforcement of federal, state, and local laws; and the geothermal regulations.

Applicable environmental stipulations found in the lease form and geothermal regulations are found starting on page 81.

Other measures such as no leasing of areas with resource conflicts or no surface occupancy are included in the following mitigating recommendations.

A. Non-Living Components

Require dust preventative measures such as surfacing or watering of trails, drill pads, roads, and construction sites when the dust content of the air exceeds State and Federal air quality standards. Federal and State requirements should mitigate most of the impact of operations upon the noxious gas content of the air. If air inversions cause the problem of noxious gases to become serious, it may have to be mitigated by the addition of air pollution control devices. Because the impacts of operations upon air temperature, air movement patterns, and non-ionizing radiation are unknown, no mitigating measures can be developed. If operations produce an adverse impact upon these components of the air quality, mitigating measures should be developed at that time.

Rock temperature reduction is an inevitable impact of geothermal energy production and cannot be mitigated. If subsidence occurs in the irrigated basins to a degree that it has an adverse impact upon farming, reinjection of water that would not contaminate ground water supplies or other measures may be required. If re-injection does not prevent subsidence, geothermal production may be required to cease. Because the impact of geothermal operations upon seismicity and hot springs is unknown, no mitigating measures can be developed. If operations produce an adverse impact upon these components of geologic structure, mitigating measures should be developed at that time.

Since entry onto the lands with equipment will increase the potential for erosion, the following measures applicable to the Klamath Basin should be required.

Existing roads and trails should be fully utilized before additional road work can be done. Permanent roads should be gravelled or paved to reduce erosion. Off road vehicle travel might be tolerable during the June-September dry period but will be prohibited when soils are wet. Roads placed in rocky, high erosion areas should be constructed by placing a pad of soil over the rocks rather than cutting below the original ground surface. All roads, drill sites and plant areas should be rehabilitated and revegetated at the time of abandonment.

No drilling or development work in the drainages above or in the meadows should be allowed.

Roads must be properly designed and constructed to minimize erosion and waste ponds must be properly sealed to prevent leakage.

B. Living Components

The best mitigating measures in areas of important wildlife habitat is not to lease the specific parcel of land or allow no surface occupancy. No surface occupancy would eliminate all drill sites, plants, and other facilities on the lands, however, angle drilling from off site locations would be allowed. Specific areas, such as Miller Creek and Klamath River Canyons should have no surface occupancy within one-fourth mile of the rim. No surface occupancy should be allowed within one-half mile of the high water line of Gerber Reservoir or within 200 yards of any live stream, laek, or reservoir.

Access roads should be limited to the minimum necessary. Roads and trails not necessary for plant operation should be put to rest and seeded with species adapted to the area.

Seed all disturbed soil areas to vegetation species adapted to the area which are beneficial to wildlife, within one year of completion or termination of the particular operation involved.

Transmission lines must be designed to prevent raptor electrocution. No surface disturbance should take place on or adjacent to special animal use areas (sagegrouse strutting and nesting grounds, antelope kidding grounds, raptor nesting sites, fawning areas, etc.) Known sites are shown on map 5.

Leasing within critical deer winter range should be based on specific site analysis. Pipelines and other barriers constructed in wildlife migration routes should be designed to allow free movement of animals.

Mitigating measures pertaining to water quality and subsequent effects on aquatic organisms are covered in applicable lease stipulations and state water quality laws.

C. Human Values

Changes in any of the basic elements of form, line, color and texture should not be evident in the Class II visual zones. Mitigating measures in this zone would include no leasing or no surface occupancy.

Changes in the basic elements may be evident in the areas of Class III scenery, but the changes should be complimentary to the existing landscape. Permanent installations should be constructed to blend into the surrounding landscape to minimize the visual impact.

Surface occupancy should be prohibited on portions of historic roads and trails containing visible remnants of past use, landmarks, or sign posts. Buffer strips should be extablished for each feature or section designated for non-occupancy.

Noise levels should not exceed 125 decibels at 25 feet. Whenever gaseous toxic emissions reach the State of Oregon minimum levels for air quality the escaping gases should be reduced.

Local residents should be given advance notice concerning exploration and development activities. Advance notice can be accomplished through procedures available in county zoning ordinances for SP-16 zones (Planned Unit Development Zones).

Mitigating measures for impacts upon known archaeological or historical sites consist of not leasing, non-occupancy, or salvage under the provisions of federal laws and geothermal lease stipulations. Areas containing National Register sites or potential National Register quality sites will be deleted from leasing. Intensive surveys for archaeological values will be done in areas where potential National Register significant sites are identified.

In addition, roads and projects should be carefully planned to avoid creating easy access to sites. Information regarding protection of archaeological resources should be distributed in areas of increased public access. Periodic, random checks should be made of projects and site areas to insure compliance with lease stipulations by the lessee.

When excessive vandalism of sites occur, access restrictions may be necessary.

V. Recommendations for Mitigation

The geothermal lease form, Part 270 and 3200 of the Code of Federal Regulations and Geothermal Resources Operating Orders contain provisions for mitigating environmental impacts. Sections of these documents that are appropriate to the Klamath Basin area of study are reproduced on the following pages.

Lease stipulations that contain measures related to the sites and not specifically mentioned in the above documents are on page 98.

GEOTHERMAL RESOURCES LEASE FORM

This lease is made pursuant to the Geothermal Steam Act of 1970 (84 Stat. 1566; U.S.C. 1001-1025) (hereinafter called "the Act") to be effective on __________________(hereinafter called the "effective date"). It is subject to all the provisions of the Act and to all the terms, conditions, and requirements of:

(a) all regulations promulgated by the Secretary of the Interior in existence upon the effective date, specifically including, but not limited to, 43 CFR Parts 3000 and 3200 and 30 CFR Parts 270 and 271,

(b) all geothermal resource operational orders(hereinafter called "GRO orders") issued pursuant thereto, all of which are incorporated here in and by reference made a part hereof.

Section 8

(1) The lessee shall conduct all operations under this lease in a workmanlike manner and in accordance with all applicable statues, regulations, and GRO orders, and all other appropriate directives of the lessor to prevent bodily injury, danger to life or health, or property damage, and to avoid the waste of resources, and shall comply with all requirements which are set forth in 43 CFR Group 3200, including, but not limited to, Subpart 3204, or which may be prescribed by the lessor pursuant to the regulations, and with the special stipulations which are attached to the lease, all of which are specifically incorporated into this lease.

Section 14

(1) The lessee shall take all mitigating actions required by the lessor to prevent:

(a) soil erosion or damage to crops or other vegetative cover on Federal or non-Federal lands in the vicinity;

(b) the pollution of land, air, or water;

(c) land subsidence, seismic activity, or noise emissions;

(d) damage to aesthetic and recreational values;

(e) damage to fish or wildlife or their habitats;

(f) damage to or removal of improvements owned by the United States or other parties; or

(g) damage to or destruction or loss of fossils, historic, or prehistoric ruins, or artifacts.

(2) Prior to the termination of bond liability or at any other time when required and to the extent deemed necessary by the lessor, the lessee shall reclaim all surface disturbances as required, removed, or cover all debris or solid waste, and so far as possible, repair the off site and on site damage caused by his activity or activities incidental there to and return access roads or trails and the leased lands to an acceptable condition including the removal of structures, if required.

(3) The Supervisor or the Authorized Officer shall prescribe the steps to be taken by lessee to protect the surface and the environment and for the restoration of the leased lands and other lands affected by operations on the leased lands and improvements theron, whether or not the improvements are owned by the United States.

(4) Timber or mineral materials may be obtained only on terms and conditions imposed by the Authorized Officer.

Section 15

(1) The lessee shall use all reasonable precautions to prevent waste of natural resources and energy, including geothermal resources, of or any minerals, and to prevent the contamination of water or brine zones any oil, gas, fresh water, or other gas or water bearing formations or zones which would threaten destruction or damage to such deposits.

(2) The lessee shall monitor noise, air, and water quality conditions in accordance with any orders of the Supervisor.

Section 18

(1) Prior to any operations under this lease, the lessee will engage a qualified archaeologist, acceptable to the Authorized Officer, to make an archaeological survey of the land to be disturbed or occupied.

(2) A certified statement, signed by the qualified archaeologist, setting out the steps taken in the survey and the findings thereof as to the existence of antiquities or other objects of historic or scientific interest, shall be submitted to the Authorized Officer.

(3) If the statement indicates the existence of such objects which might be disturbed by operations under this lease, the lessee shall take such steps as may be required by the Authorized Officer, including archaeological salvage.

(4) The responsibility for the cost of the certificate, survey, and salvage will be borne by the lessee, and such salvaged property shall remain the property of the lessor or the surface owner.

(5) The lessee shall immediately bring to the attention of the Authorized Officer any antiquities or other objects of historic or scientific interest, including but not limited to historic or prehistoric ruins, fossils, or artifacts discovered as a result of operations under this lease, and shall leave such discoveries intact.

(6) Failure to comply with any of the terms and conditions imposed by the Authorized Officer with regard to the preservation of antiquities may constitue a violation of the Antiquities Act (16 U.S.C. 431-433).

Part 270 of The Code of Federal Regulations

270.11 General Functions.

The Supervisor is authorized and directed to carry out the provisions of this part. He will require compliance with the terms of geothermal leases, with the regulations in this part and the applicable regulations in 43 CFR Group 3200, and with the applicable statutes. He shall act on all applications, requests, and notices required in this part. In executing his functions under this part, the Supervisor shall ensure that all operations, within the area of operations, will conform to the best practice and are conducted in such manner as to protect the deposits of the leased lands and to result in the maximum ultimate recovery of geothermal resources, with minimum waste, and are consistent with the principles of the use of the land for other purposes and of the protection of the environment. Inasmuch as conditions in one area may vary widely from conditions in another area, the regulations in this part are intended to be general in nature. Detailed procedures hereunder in any particular area will be covered by GRO orders. The requirements to be set forth in GRO orders relating to surface resources or uses will be coordinated with the appropriate land management agency. The Supervisor may issue oral orders to govern lease operations, but such orders shall be confirmed in writing by the Supervisor as promptly as possible. The Supervisor may issue other orders and rules to govern the development and method of production of a deposit, field, or area. Prior to the issuance of GRO orders and other orders and rules and the approval of any plan of operations, the Supervisor shall consult with, and receive comments from appropriate Federal and State agencies, lessees, operators, or interested parties. Before permitting other operations on the leased land, the Supervisor shall determine if the lease is in good standing, whether the lessee is authorized to conduct operations, has filed an acceptable bond, and has an approved plan of operations.

270.15 Well Spacing And Well Casing.

The Supervisor shall approve proposed well-spacing and well-casing programs or prescribe such modifications to the programs as he determines necessary for proper development, giving consideration to such factors as:

(a) Topographic characteristics of the area;

(b) hydrologic, geologic, and reservoir characteristics of the field;

(c) the number of wells that can be economically drilled to provide the necessary volume of geothermal resources for the intended use;

(d) protection of correlative rights;

(e) minimizing well interference;

(f) unreasonable interference with multiple use of lands; and

(g) protection of the environment, including ground water quality.

270.30 Lease Terms, Regulations, Waste, Damage, And Safety.

(a) The lessee shall comply with the lease terms, lease stipulations, applicable laws, and regulations and any amendments thereof, GRO orders, and other written or oral orders of the Supervisor. All oral orders (to be confirmed in writng as provided in 270.11) are effective when issued unless otherwise specified.

(b) The lessee shall take all reasonable precautions to prevent:

(1) Waste;

(2) damage to any natural resource including trees and other

vegetation, fish, and wildlife, and their habitat;

(3) injury or damage to persons, real or personal property; and

(4) any environmental pollution or damage.

(c) Any significant effect on the environment created by the lessee's operations or failure to comply with environmental standards shall be reported to the Supervisor within 24 hours and confirmed in writing within 30 days.

270.31 Plan Of Operation.

Prior to commencing any operations on the leased lands or on any lands covered by a unit or cooperative agreement, the lessee shall submit in triplicate and obtain the approval of the Supervisor and the appropriate land management agency of a plan of operation for the area. Such plan shall include:

(a) The proposed location of each well including a layout showing the position of the mud tanks, reserve pits, cooling towers, pipe racks, etc.;

(b) Existing and planned access and lateral roads;

(c) Location and source of water supply and road building material;

(d) Location of campsites, airstrips, and other supporting facilities;

(e) Other areas of potential surface disturbance;

(f) The topographic features of the land and the drainage patterns;

(g) Methods for disposing of waste material;

(h) A narrative statement describing the proposed measures to be taken for protection of the environment, including, but not limited to, the prevention or control of:

(1) fires;

(2) soil erosion;

(3) pollution of surface and ground water,

(4) damage to fish and wildlife or other natural resources;

(5) air and noise pollution; and

(6) hazards to public health and safety during lease activities;

(i) All pertinent information or data which the Supervisor may require to support the plan of operations for the utilization of geothermal resources and the protection of the environment;

(j) Provisions for monitoring deemed necessary by the Supervisor to ensure compliance with these regulations for the operations under the plan; and

(k) A requirement for the collection of data concerning the existing air and water quality, noise, seismic, and land subsidence activities, and ecological system of the leased lands covering a period of at least one year prior to the submission of a plan for production. The informations required for paragraphs (a) through (f) of this section may be shown on a map or maps available from State or Federal sources.

270.41 Pollution.

The lessee shall comply with all Federal and State standards with respect to the control of all forms of air, land, water, and noise pollution, including, but not limited to, the control of erosion and the disposal of liquid, solid, and gaseous wastes. The Supervisor may, in his discretion, establish additional and more stringent standards, and if he does so, the lessee shall comply with those standards. Plans for disposal of well effluents must take into account effects on surface and subsurface waters, plants, fish, and wildlife, and their habitats, atmosphere, or any other effects which may cause or contribute to pollution, and such plans must be approved by the Supervisor before action is taken under them.

270.12 Noise Abatement.

The lessee shall minimize noise during exploration, development, and production activities. Welfare of the operating personnel and the public must not be affected as a consequence of the noise created by the expanding gases. The method and degree of noise abatement shall be as approved by the Supervisor.

270.43 Land Subsidence And Seismic Activity.

In the event subsidence or seismic activity results from the production of geothermal resources, as determined by monitoring activities by the lessee or a government body, the lessee shall take such action as required by the lease or by the Supervisor.

270.44 Pits And Sumps.

The lessee shall provide and use pits and sumps of adequate capacity and design to retain all materials and fluids necessary to drilling, production, or other operations unless otherwise specified by the Supervisor. In no event shall the contents of a pit or sump be allowed to:

(a) Contaminate streams, artificial canals or waterways, ground waters, lakes, or rivers;

(b) Adversely affect environment, persons, plants, fish, and wildlife, and their habitats; or

(c) Damage the aesthetic values of the property or adjacent properties. When no longer needed, pits and sumps are to be filled and covered and the premises restored to a near natural state, as prescribed by the Supervisor.

270.45 Well Abandonment.

The lessee shall promptly plug and abandon any well on the leased land that is not used or useful. No well shall be abandoned until its lack of capacity for further profitable production of geothermal resources has been demonstrated to the satisfaction of the Supervisor. Before abandoning a producible well, the lessee shall submit to the Supervisor a statement of reasons for abandonment and his detailed plans for carrying on the necessary work. The detailed plans shall provide for the preservation of fresh water aquifers and for the prevention of intrusion into such aquifers of saline or polluted waters. A producible well may be abandoned only after receipt of written approval by the Supervisor. No well shall be plugged and abandoned until the manner and method of plugging have been approved or prescribed by the Supervisor. Equipment shall be removed, and premises at the well site shall be restored as near as reasonably possible to its original condition immediately after plugging operations are completed on any well, except as otherwise authorized by the Supervisor. Drilling equipment shall not be removed from any suspended drilling well without taking adequate measures to close the well and protect the subsurface resources.

270.18 Departure From Orders.

The Supervisor may prescribe or approve either in writing or orally, with prompt written confirmation, variances from the requirements of GRO orders and other orders issued pursuant to these regulations, when such variances are necessary for the proper control of a well, conservation of natural resources, protection of human health and safety, property, or the environment. The Supervisor shall inform appropriate Federal and State agencies, of any action taken under this section.

270.76 Annual Report Of Compliance With Environmental Protection Requirements.

The lessee shall submit annually a report giving a full account of the actions taken to comply with the appropriate Federal and State regulations or requirements of the Supervisor pertaining to the protection of the surface and subsurface environment. This report shall include but is not limited to such matters as:

(a) Noise abatement;
(b) Water quality;
(c) Air quality;
(d) Erosion control;
(e) Subsidence and seismic activity;
(f) Rehabilitation activities;
(g) Waste disposal; and
(h) Environmental effects on flora and fauna.

Part 3200 Of The Code Of Federal Regulations

3203.6 Plan Of Operation.

A lessee will be required to submit a plan of operation pursuant to 30 CFR 270.34, prior to entry upon the leased lands for any purpose other than casual use as that term is defined in 3209.0-5 (d) of this chapter. Operations will not be permitted on the lands until the plan of operation has been approved.

3204.1 General.

A lessee shall comply with and be bound by the following general terms and conditions, the specific requirements contained in the lease stipulations and any GRO orders that may be issued pursuant to 30 CFR 270.11. Assuring compliance with the requirements of this section is the responsibility of the Supervisor as to the lands within the area of operations and is the responsibility of the appropriate land management agency as to the remaining lands in the lease.

(a) Public Access.

(1) The lessee shall permit free and unrestricted public access to and upon the leased lands for all lawful and proper purposes except in areas where such access would unduly interfere with operations under the lease or would constitute a hazard to health and safety. Restrictions on access will not be allowed without prior approval.

(2) During construction, the lessee shall regulate public access and vehicular traffic to protect the public, wildlife, and livestock from hazards associated with the project. For this purpose, the lessee shall provide warnings, fencing, flag men, barricades, and other safety measures as appropriate.

(c) Pollution Abatement. The lessee shall comply with all Federal and State standards and all applicable local standards with respect to the control of all forms of air, land, water, and noise pollution, including, but not limited to, the control of erosion and the disposal of liquid, solid, and gaseous wastes. The Supervisor may, in his discretion, establish additional and more stringent standards, and, if he does so, the lessee shall comply with those standards. The lessee, in addition to any other action required by those standards, shall take the following specific actions:

(1) Pesticides and Herbicides. The lessee shall comply with all rules issued by the Department of the Interior and the Environmental Protection Agency pertaining to the use of poisonous substances on public lands.

(2) Water Pollution. The lessee shall conduct lease operations and maintenance in accordance with Federal and State water quality standards and public health and safety standards, and applicable local water quality standards and public health and safety standards. Toxic materials shall not be released into any surface waters or underground waters. Reinjection of waste geothermal fluids into geothermal or other suitable aquifers will be permitted upon approval of the lessee's plan of operation submitted pursuant to 30 CFR 270.34.

(3) Air Pollution. The lessee shall control emissions from operations in accordance with Federal and State air quality standards, and applicable local air quality standards.

(4) Erosion Control. The lessee shall minimize disturbance to vegetation, drainage channels, and streambanks. The lessee shall employ such soil and resource conservation and protection measures on the leased lands as the Supervisor deems necessary.

(5) Noise Control. The lessee shall control noise emissions from operations, in accordance with Federal and State noise emission standards, and applicable local noise emmission standards.

(d) Sanitation and Waste Disposal. The lessee shall remove or dispose of all waste material generated in connection with the exploration, development, production, and transportation operations in a manner set forth in the approved plan of operation submitted pursuant to 30 CFR 270.34.

(e) Land Subsidence, Seismic Activity. The lessee shall take precautions necessary to minimize land subsidence or seismic activity which could result from production of geothermal resources and the disposal of waste fluid where such activity could damage or curtail the use of the geothermal resources or other resources, or other uses of the land and take such measures as stipulated to:

(1) monitor operations for land subsidence and for seismic activity; and

(2) maintain, and when requested, make available to the lessor, records of all monitoring activities.

(f) Aesthetics. The lessee shall take aesthetics into account in the planning, design, and construction of facilities on the leased premises.

(g) Fish and Wildlife. The lessee shall employ such measures as are deemed necessary to protect fish and wildlife and their habitat.

(h) Antiquities and Historical Sites. The lessee shall conduct activities on discovered, known, or suspected archaeological, paleontological, or historical sites in accordance with lease terms or specific instructions.

(i) Restoration. The lessee shall provide for the restoration of all disturbed lands in an approved manner.

(j) The lessee shall submit annual reports to the authorized officer on compliance with the requirements of paragraphs (b)-(i) of this section and report within 24 hours, and if the report is oral, shall confirm the report in writing within 30 days, any significant environmental damage suffered by the lands subject to his lease. However, if, after drilling operations have begun, the lessee is required to submit a similar report under 30 CFR 270.30 and 270.76, he may fulfill the requirement of this subsection by submitting to the authorized officer a copy of that report.

3204.2 Waste Prevention.

All leases shall be subject to the condition that the lessee will, in conducting his exploration, development, and producing operations, use all resonable precautions to prevent waste of geothermal resources and other natural resources found or developed in the leased lands.

Geothermal Resource Operational Order No.4.

Effective August 1, 1975

Adverse environmental impacts from geothermal-related activity shall be prevented or mitigated through enforcement of applicable Federal, State, and local standards, and the application of existing technology. Inability to meet these environmental standards or continued violation of environmental standards due to operations of the lessee, after notification, may be construed as grounds for the Supervisor to order a suspension of operations.

The lessee shall be responsible for the monitoring of readily identifiable localized environmental impacts associated with specific activities that are under the control of the lessee. Monitoring of environmental impacts may be conducted by the use of aerial surveys, inspections, periodic samplings, continuous recordings, or by such other means or methods as required by the Supervisor. Due to the differing natural environmental conditions among geothermal areas, the extent and frequency of such monitoring activities will be determined by the Supervisor on an individual basis. In the event the Supervisor determines that the degree and adequacy of existing environmental protection regulations in certain areas are insufficient, the Supervisor may establish additional and more stringent requirements by the issuance of field orders or by modifying existing orders.

(1) Aesthetics. The lessee shall reduce visual impact, where feasible, by the careful selection of sites for operations and facilities on leased lands. The design and construction of facilities shall be conducted in a manner such that the facilities will blend into the natural environmental setting of the area by the appropriate use of landscaping, vegetation, compatible color schemes, and minimum profiles. Native plants or other compatible vegetation shall be used, where possible, for landscaping and revegetation.

(2) Land Use and Reclamation. Operating plans shall be designed so that operations will result in the least disturbance of land, water, and vegetation. Existing roads shall be used where suitable. Entry upon certain environmentally fragile land areas, as designated by the surface management agency, may be either seasonally restricted or restricted to special vehicles or transportation methods which will minimize disturbance to the surface or other resources as specified by the Supervisor and surface management agency.

Operating plans shall provide for the reclamation and revegetation of all disturbed lands in a manner approved by the Supervisor and the appropriate surface management agency. Land reclamation may include preparation and seeding with prescribed wildlife food and plant cover or improved and acceptable substitutes thereof which will equal or enhance the food values for indigenous wildlife species and domesticated animals. Temporary fencing for such reclaimed areas may be required to facilitate restoration thereof.

The lessee shall at all times maintain the leased lands in a safe and orderly condition and shall perform the operations in a workmanlike manner. The lessee shall remove or store all supplies, equipment, and scrap in a timely and orderly fashion.

Operations under a geothermal lease shall not unreasonably interfere with or endanger operations under any other lease, license, claim, permit, or other authorized use on the same lands.

(3) Public Access. The public shall have free and unrestricted access to geothermal leased lands, excepting however, where restrictions are necessary to protect public health and safety or where such public access would unduly interfere with the lessee's operations or the security thereof. The lessee shall provide warning signs, fencing, flagmen, barricades or other safety measures deemed necessary by the Supervisor to protect the public, wildlife, and livestock from hazardous geothermal or related activities.

(4) Recreation. Recreational values shall be adequately protected through planning and designing of site development to minimize the aesthetic degradation of the particular recreation area. The lessee shall generally be restricted from surface locations for drilling and other lease operations within 61 metres (200 ft) of established recreation sites and access routes thereto. However, the lessee may relocate a recreational site and/or access routes thereto when approved by the Supervisor with the concurrence of the land management agency.

(5) Slope Stability and Erosion Control. Operations shall be conducted in such a manner so as to minimize erosion and disturbance to natural drainage. The lessee shall provide adequate erosion and drainage control to prevent sediments from disurbed sites from entering water courses for soil and natural resource conservation protection.

Mitigating measures to lessen environmental damage may include reseeding of disturbed soils, chemical stabilization, and dust and erosion control on well sites, roads, and construction areas.

All operation plans shall give proper consideration to the potential hazards of slope instability. Where potentially unstable ground conditions exist, design of proposed roads, drill sites, and surface facilities shall be approved by and constructed under the supervision of a qualified engineer or engineering geologist satisfactory to the Supervisor.

(6) Biota. The lessee shall conduct all operations in such a manner as to afford reasonable protection of fish, wildlife, and natural habitat. The lessee shall take such measures as are necessary for the conservation of endangered and threatened species of flora and fauna as set forth in applicable executive orders, regulations, and State or Federal legislation such as the Endangered Species Act of 1973 and the Migratory Bird Act of 1966. When such species would be adversely affected by the lessee's operations on the leased lands, the lessee shall implement those measures necessary to minimize or elimate such adverse effects and to protect the flora and fauna as specified by the Supervisor in accordance with recommendations by appropriate Federal and State Agencies. Such measures may be in addition to provisions set forth in the lease or accompanying stipulations.

(7) Cultural Resources Preservation. The lessee shall exercise due diligence in the conduct of his operations to protect and preserve significant archaeological, historical, cultural, paleontological, and unique geologic sites. The lessee shall not disturb any known cemetery or burial ground of any group or culture.

Previously unknown sites uncovered by the lessee shall be immediately reported to the Supervisor, and operations on the particular site shall cease until said site can be assessed for its archaeological value and preservation. Necessary controls and remedial actions for the protection and preservation of cultural resources shall be issued on an individual site basis by the Supervisor as warranted.

The preservation, restoration, maintenance, and nomination of all resources for purposes of the National Register of Historic Places shall be in accordance with the provisions of Executive Order 11593 (36 FR 8921) entitled, "Protection and Enhancement of the Cultural Environment," or any amendments thereto.

(8) Subsidence and Seismicity. Surveying of the land surface prior to and during geothermal resources production will be required for determining any changes in elevation of the leased lands. Lessee shall make such resurveys as required by the Supervisor to ascertain if subsidence is occurring. Production data, pressures, reinjection rates, and volumes shall be accurately recorded and filed monthly

with the Supervisor as provided in 30 CFR 270.37. In the event subsidence activity results from the production of geothermal resources, as determined by surveys by the lessee or a governmental body, the lessee shall take such mitigating actions as are required by the lease terms and by the Supervisor.

If subsidence is determined by the Supervisor to present a significant hazard to operations or adjoining land use, then the Supervisor may require remedial action including, but not limited to, reduced production rates, increased injection of waste ot other fluids, or a suspension of production.

(c) Reservoir Data. Initial reservoir pressure and temperature shall be reported to the Supervisor in duplicate on Well Completion or Recompletion Report (Form 9-330C) for all completed wells within 30 days after the completion of measurements or tests conducted for the purpose of obtaining such data. Initial production test data including steamwater ratio, surface pressure, and temperature, quality, and quantity of well effluent shall also be filed with the Supervisor on Form 9-330C within 30 days after a well is completed.

(d) Seismicity. The installation of seismographs or other like instruments in producing geothermal areas for the purpose of detecting potential seismic activity may be initiated from time to time by appropriate public agencies. Lessees shall cooperate with the appropriate public agencies in this regard. The lessee and the appropriate public agency should take care not to unreasonably interfere with or endanger each other's respective operations. The Supervisor shall coordinate such detection programs between the appropriate public agency conducting the program and the lessee.

Where induced seismicity caused by the production of geothermal fluids is determined to exist by the Supervisor, then the Supervisor may require the lessee to install such monitoring devices as necessary to adequately quanitify the effects thereof. If induced seismicity is determined to represent a significant hazard, the Supervisor may require remedial actions including, but not limited to, reduced production rates, increased injection of waste or other fluids, or suspension of production.

(9) Pollution, Waste Disposal, and Fire Prevention. The lessee shall comply with all applicable Federal and State standards with respect to the control of all forms of air, land, water, and noise pollution, including the control of erosion and the disposal of liquid, solid, and gaseous wastes. The Supervisor may, at his discretion, establish additional and more stringent standards. Plans for disposal of well

effluents must be approved by the Supervisor before any implementation action is undertaken. Immediate corrective action shall be taken in all cases where pollution has occurred.

The lessee shall timely remove or dispose of all waste including human waste, trash, refuse, and extraction and processing waste generated in connection with the lessee's operations in a manner acceptable to the Supervisor.

The lessee shall provide safeguards to minimize potential accidental fires and shall instruct field personnel in fire-prevention methods. The lessee shall maintain firefighting equipment in working order at strategic locations on the leased lands.

(a) Pollution Prevention. In the conduct of all geothermal operations, the lessee shall not contaminate any natural waters and shall minimize adverse effects on the environment.

(1) Liquid Disposal. Liquid well effluent or the liquid residue thereof containing substances, including heat, which may be harmful or injurious and cannot otherwise be disposed of in conformance with Federal, State, and regional standards, shall be injected into the geothermal resources zone or such other formation as is approved by the Supervisor.

Toxic drilling fluids shall be disposed of in a manner approved by the Supervisor and in conformance with applicable Federal, State, and regional standards.

(2) Solid Waste Disposal. Drill cuttings, sand, precipitates, and other solids shall be disposed of as directed by the Supervisor either on location or at other approved disposal sites. Containers for mud additives for chemicals and other solid waste materials shall be disposed of in a manner and place approved by the Supervisor.

(3) Air Quality. Noncondensible gases such as carbon dioxide, ammonia, and hydrogen sulfide may be vented or ejected into the atmosphere, provided, however, that the volume and the measured concentration of such vented gas or gases shall not exceed applicable Federal, State, or regional air pollution standards. Copies of each permit issued by the appropriate air pollution control agency and the reports required thereunder shall be submitted to the Supervisor.

(4) Pits and Sumps. Pits and sumps shall be lined with impervious material and purged of environmentally harmful chemicals and precipitates before backfilling. In no event shall the contents of a pit or sump be allowed to contaminate streams, lakes, and ground waters. Pits and sumps shall be constructed in a manner and in such locations so as to minimize damage to the natural environment and aesthetic values of the lease or adjacent property. When no longer used or useful, pits and sumps shall be backfilled and the premises restored to as near a natural state as reasonably possible. Temporary fencing of unattended pits and sumps to protect wildlife, livestock, and the public may be required by the Supervisor and the surface management agency.

(5) Production Facilities Maintenance. Production facilities shall be operated and maintained at all times in a manner necessary to prevent pollution. The lessee's field personnel shall be instructed in the proper maintenance and operations of production facilities for the prevention of pollution.

(b) Inspection and Reports. Lessees shall comply with the following pollution inspection and reporting requirements.

(1) Pollution Inspections. Drilling and production facilities shall be inspected daily by the lessee. Appropriate preventative maintenance shall be performed as necessary to prevent failures and malfunctions which could lead to pollution. Wells and areas not under production shall be inspected by the lessee at intervals prescribed by the Supervisor. Necessary repairs or maintenance shall be made as required.

(2) Pollution Reports. All pollution incidents shall be reported orally within 18 hours to the appropriate Geothermal District Supervisor and shall be followed within 30 days thereof by a written report stating the cause and corrective action taken.

(10) Water Quality. The primary responsibility for water quality and pollution control has been delegated to the States where such have standards approved by the Environmental Protection Agency. Such State standards must meet basic Federal requirements prohibiting the deterioration of waters whose existing quality is higher than established water quality standards. The lessee shall comply with the State water quality control organization's standards in such States as have federally-approved standards. The Supervisor, at his discretion, may establish additional and more stringent standards.

The lessee shall file, in duplicate, a detailed water analysis report for all completed geothermal wells within 30 days after completion and annually thereafter or as otherwise specified by the Supervisor. Unless otherwise prescribed by the Supervisor, such analyses shall include a determination of arsenic, boron, radioactive content, and radioactivity of the produced fluids. In the event that a health hazard exists, the Supervisor shall require appropriate and safety precautions, periodic monitoring, or the suspension of production.

(11) Noise Abatement. The lessee shall minimize noise during exploration, development, and production activities. The method and degree of noise abatement shall be as approved by the Supervisor.

The lessee shall conduct noise level measurements during exploration, development, and production operations to determine the potential objectionability to nearby residents as well as the potential health and safety danger due to noise emissions.

Noise level measurements and accompanying data shall be filed with the Supervisor. Such data shall provide the basis for operational and noise control decisions by the Supervisor and shall be based on an assessment of the noise relative to Federal or State criteria including adjustments for the area involved, meteorological conditions, and the time of day of the noise occurrence.

The lessee shall comply with Federal occupational noise exposure levels applicable to geothermal activity under the Occupational Safety and Health Act of 1970 as set forth in 29 CFR 1910.95, which are incorporated herein by reference, or with State standards for protection of personnel where such State standards are more restrictive than Federal standards.

Lease Stipulations

1. The Lessee will apply to the Authorized Officer for a tramroad right-of-way permit pursuant to 43 CFR 2811, over lands and roads owned or controlled by the BLM for the purpose of obtaining access to the leased area.

2. Activities employing wheeled or tracked vehicles shall be conducted in a manner suitable to the Authorized Officer and the Supervisor so as to minimize surface damage. Existing roads and trails shall be used whenever possible.

3. All access, haul, and other support roads and trails shall be located, constructed, and maintained in accordance with bureau standards and specifications as required by the Authorized Officer. Roads constructed in rocky, highly erosive areas shall be constructed by placing the road base on top of the rocks.

4. Operations within 600 feet of any surface waters or wet soil areas such as streams, springs, seeps, reservoirs, or meadows, will be permitted only if specifically approved writing by the Authorized Officer and the Supervisor.

5. The Lessee shall not occupy or use the surface of designate area. The Lessee, however, is authorized to employ directional drilling to the geothermal resources provided that such drilling will not disturb the surface of the restricted land.

6. Backfilling, final grading, revegetation, and removal of surface supporting facilities shall be completed within one year after completion or termination of the particular operation involved, unless the Authorized Officer extends such time.

7. The Lessee shall construct and color all permanent installations in such a manner that they are harmonious and accentuating to the surrounding landscape.

8. Restricted access will be provided by the Lessee when specifically requested by the Authorized Officer and the Supervisor.

VI. Relationship Between Short-Term Use and Long-Term Productivity

The existing use of the land is for livestock grazing, timber harvests, wildlife, recreation, and watershed. The proposed action, geothermal leasing followed by development, may remove some of the land from production for some of the existing uses. Uses such as livestock grazing, may be able to co-exist with the geothermal activities, and may even have their productivity increased by the geothermal activities, such as increasing year-long water.

Geothermal development will utilize the geothermal resources to help meet out nation's growing energy needs. Geothermal leasing and development will commit the land and its resources for a period of 20 to 50 years. When the production capacity of the geothermal field is depleted, the leases will be terminated, the plant removed, and the land restored to near its original condition. The land could then be returned to the original use at near the original productivity.

VII. Irreversible and Irretrievable Commitments

1. Removal of thermal energy and water from the geothermal field. These resources are renewable, but not within the life span of a specific project.

2. Compaction may result in land subsidence by the removal of geothermal fluids.

3. Roads and plant sites may not be returned to the original landscape.

4. The soil that is eroded cannot be returned to the original condition.

5. The plants which will be removed may not be replaced by the original plant species.

6. Archaeological sites are a fragile resource. If disturbed or destroyed by the proposed action the scientific information of the specific site cannot be replaced.

VIII. Intensity of Public Interest

Public interest in geothermal development in the Klamath Basin ranges from curiosity to deep involvement. Persons that have been heating their homes and domestic water by means of geothermal heat, have been quietly using this resource for years. In 1970 the City of Klamath Falls passed an ordinance to limit the volume of geothermal wastes that could enter their sewer system. During the past two years, companies have been leasing private land primarily in the valleys for geothermal exploration.

Klamath Basin residents have heard and read about geothermal resources but are not fully aware of what would be involved in setting up a producing field.

Comments received from groups and individuals range from approval of leasing land in the Klamath Basin, to concern over fish and animal life, to requests for further information.

Oregon Institute of Technology is pioneering in research on a variety of uses of geothermal energy including home heating, industry, and agriculture.

Klamath County is studying the feasibility of using hot water from a new well at the museum to heat the county courthouse.

Some Klamath County residents speculate that the geothermal heat source will not be sufficient to produce electrical power like is being done at the Geysers in California. Many feel that the more subtle uses, like the ones being studied at O.I.T., will add small but meaningful increments to the basin's economy.

Geothermal activity is front page news in Klamath County. A wildcat well is expected to be drilled in the hills northeast of Klamath Falls during the coming year. Information gained in this venture could answer questions as to the probable extent of the geothermal field. Meanwhile, basin residents continue to be interested in the possibility of added uses of this resource.

IX. Persons, Groups and Governmental Agencies Consulted

During April and May 1975 letters were sent out to several persons and groups inviting comments on the Klamath Basin EAR. In addition, a statewide news release was issued in June for the same purpose.

Federal Agencies -

U.S. Geological Survey
Menlo Park, California

Fish & Wildlife Service
Division of River Basin Studies
Portland, Oregon

U.S. Forest Service
Portland, Oregon

Fremont Forest Supervisor
Lakeview, Oregon

Refuge Manager
Tulelake, California

Soil Conservation Service
Klamath Falls, Oregon

Environmental Protection Agnecy
Seattle, Washington

Burea of Land Management
Branch of Energy & Minerals
Denver, Colorado

Soil Conservation Service
Portland, Oregon

Winema Forest Supervisor
Klamath Falls, Oregon

U.S. Bureau of Reclamation
Klamath Falls, Oregon

State Agencies -

Department of Environmental Quality
Klamath Falls, Oregon

County Extension Service
Klamath Falls, Oregon

State Clearing House
Salem, Oregon

Oregon Dept. of Geology & Minerals
Salem, Oregon

Governor of Oregon
Salem, Oregon

Oregon Wildlife Commission
Klamath Falls, Oregon

State Engineer
Salem, Oregon

State Water Resource Board
Salem, Oregon

Groups and Individuals -

Oregon Environmental Council
Portland, Oregon

Oregon Wildlife Federation
Portland, Oregon

Oregon Student Public Interest Research Group
Portland, Oregon

Survival Center
Eugene, Oregon

Wilderness Society
Eugene, Oregon

P.U.R.E.
Bend, Oregon

Sierra Club
Eugene, Oregon

Audubon Society of Oregon
Portland, Oregon

Dept. of Fisheries & Wildlife
O.S.U.
Corvallis, Oregon

Isaak Walton League
Klamath Falls, Oregon

Klamath County Nature Society
Klamath Falls, Oregon

Klamath County Chamber of Commerce
Klamath Falls, Oregon

Rogue Flyfishers
Ashland, Oregon

Weyerhaeuser Co.
Klamath Falls, Oregon

O'Connor Livestock
Klamath Falls Oregon

Pope Ranches
Merrill, Oregon

Oregon High Desert Study Group
Eugene, Oregon

Oregon Museum of Natural History
Eugene, Oregon

Dept. of Environmental Services
Portland, Oregon

Oregon Historical Society
Portland, Oregon

Oregon Ecological Society
Portland, Oregon

Sierra Club
Klamath Falls, Oregon

Oregon Institute of Technology
Klamath Falls, Oregon

Oregon Game Council
Klamath Falls, Oregon

Southern Oregon Timber Assoc.
Medford, Oregon

Langell Valley Irrigation District
Bonanaza, Oregon

J.K. O'Neill
Central Point, Oregon

Klamath County SWCD
Bonanza, Oregon

X. Participating Staff

This EAR was prepared by B.L.M. personnel in the Lakeview and Medford Districts with technical assistance and information supplied by the following:

Dan Eastman and Wendall Stout - Oregon Department of Fish and Wildlife
Harry Drew - Klamath County MUseum
Gene Favell - Favell Museum, Klamath Falls
William H. Lee - U.S. Geological Survey
David Williams - National Weather Service (Dept. of Commerce)
Robert Percy - D.E.Q.
David Pranghofer - Weyerhaeuser Co.
Dick Thompson - B.L.M. Electronic Technician
John Lund - Professor, O.I.T.
Marvin J. Furman - U.S. Geological Survey

The B.L.M. interdisciplinary team was as follows:

Christopher Broili - Geologist
Lee DeMoulin - Soils - Medford District
Larry Doughty - Wildlife Specialist
William Cannon - Archaeologist
Marvin Hammersmark - Range/Watershed Specialist
Dennis Hill - Recreation Specialist
Don King - Fisheries - Medford DIstrict
Bill Johnson - Forester
Mike Mackey - Surface Protection Specialist
Melvin Schlagel - Realty Specialist
John R. Schaub - Forester - Medford District
Maurice Ziegler - Team Leader, Lost River Area Manager

XI. Interdisciplinary Team Recommendations

The interdisciplinary team recommends that the alternative of leasing land with low resource conflict be adopted.

Unrestrictive leasing cannot be allowed because of the unmitigated impacts that have been brought out in this analysis. Impacts to wildlife, scenic, cultural, and water resources cannot be mitigated in some of the land area with the possibility of full production of a geothermal field.

The team concludes that there are several reasons why no leasing of any B.L.M. land in the study area is unrealistic:

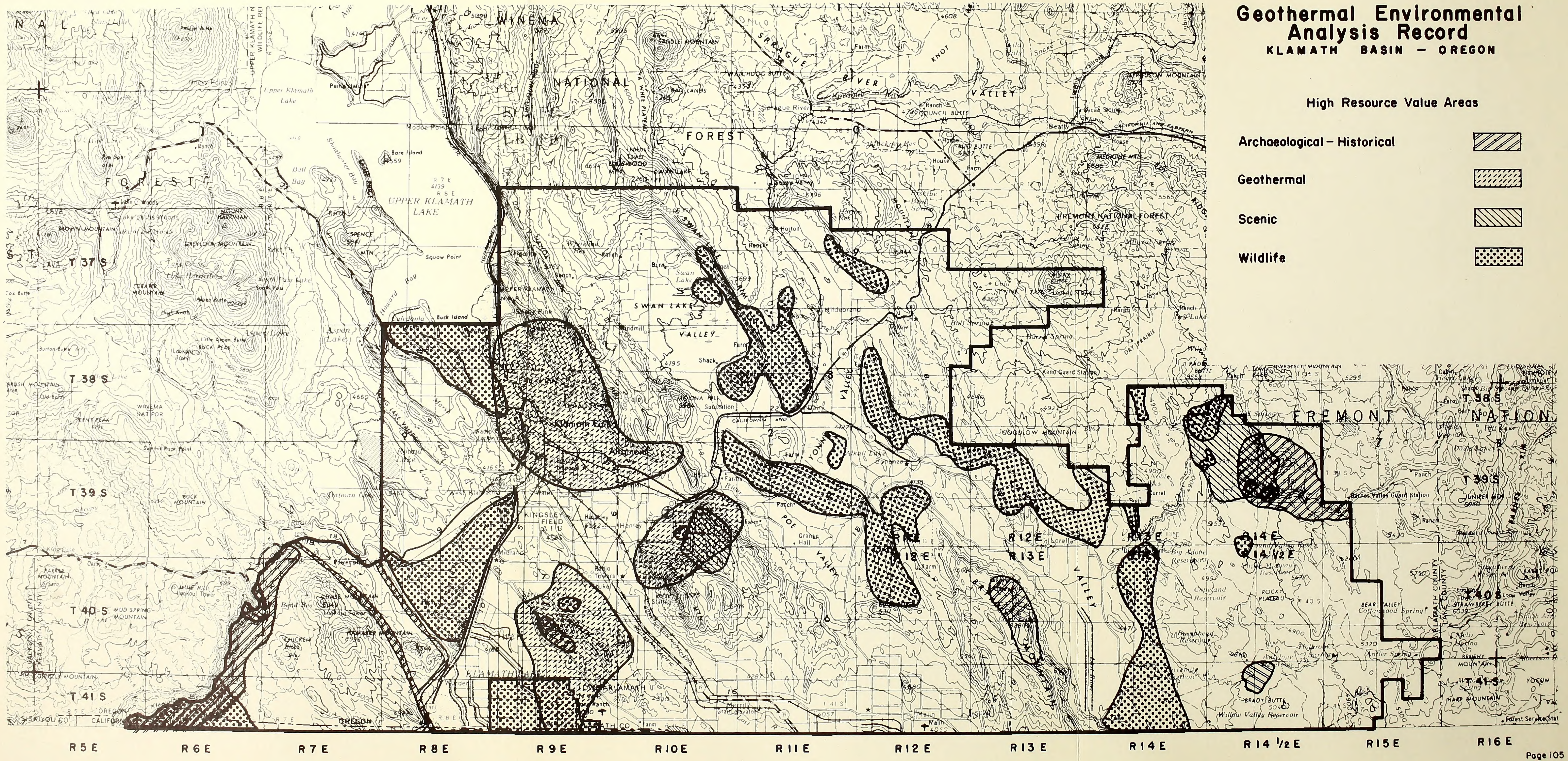
(1) Adverse impacts on all of the studied portions of the environment in some areas are slight or easily mitigated.

(2) It is unlikely that all of the federal lands would be leased. Since opening the land to potential leasing in January, 1974, applications have been made on less than one-fourth of the B.L.M. land in the EAR area.

(3) It is also unlikely that work beyond the exploration stage will happen on the majority of acres that have lease applications. Exploration has the least environmental impact of the stages of geothermal development.

(4) Records of competitive sales on other potential geothermal areas in the Oregon and adjacent parts of northern California show that not all lease blocks offered are sold.

Geothermal Environmental Analysis Record
KLAMATH BASIN – OREGON



High Resource Value Areas

Archaeological – Historical ▨

Geothermal ▨

Scenic ▨

Wildlife ▨

XII. Signatures

Maurice Ziegler
Team Leader

November 6, 1975
Date

Reviewed By:

Donald J. Schofield
District Manager, Medford

17 November 1975
Date

Marvin LeNoue
District Manager, Lakeview

November 14, 1975
Date

Serial Number

Form 3980–1
(September 1970)
(formerly 3820–1)

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

State Oregon, California, Nevada

MINERAL REPORT

TECHNICAL REPORT
on
Geothermal Energy Development
in
South Central Oregon
Northeastern California
Northwestern Nevada

(Title)

LANDS INVOLVED

Lake County, Oregon
Klamath County, Oregon
Modoc County, California
Washoe County, Nevada

September 3, 1974
(Date)

By

Christopher J. Broili
Geologist

Technical Review

Management Review

GPO 830-392

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March 3, 1849

IN REPLY REFER TO

United States Department of the Interior

BUREAU OF LAND MANAGEMENT
Lakeview District

TECHNICAL REPORT
on
Geothermal Energy Development
in
South Central Oregon
Northeastern California
Northwestern Nevada

by

Christopher J. Broili

Introduction

The data in this technical report is supplementary to data included in the Environmental Analysis Record. Both the technical and the environmental data must be considered together to reach a judgement as to the conduct of a leasing program. The technical information presented here is equally applicable throughout all of south central Oregon, northeastern California, and Northwestern Nevada. The final Environmental Statement for the Geothermal Leasing Program, covering all Federal lands, was published in October 1973, additional data is contained therein.

Proposed Action

The proposal is to lease federally owned potential geothermal resources in south central Oregon, northeastern California, and northwestern Nevada.

The geothermal energy leasing program would be conducted under the Geothermal Steam Act of 1970 and the regulations in 43 CFR 3200 and 30 CFR 270 which became effective January 1, 1974.

The proposal involves:

(A) The approval of "Notices of Intent to Conduct Geothermal Resource Explorations" on areas not connected with a lease (Form 3200-9).

(B) The issuance of Noncompetitive Geothermal Resource Leases (Form 3200-21).

(C) The issuance of Geothermal Resource Leases (Form 3200-21) on Known Geothermal Resource Areas by Competitive bidding.

Geothermal Resource Leases, both noncompetitve and competitive, are between 640 and 2560 acres each. Such leases are issued for an initial term of 10 years and the term is extended if commercial production is reached.

The areas under consideration are several hot spring areas in south central Oregon, northeastern California, and northwestern Nevada. Most of the land is national resource land with the remainder privately owned with no federally owned minerals.

Geothermal Resources

The earth is a tremendous reservoir of thermal (heat) energy. Heat flows beneath the surface and dissipates. This is usually not noticeable because it is dissipated in small quantities.

The increase of heat with depth is called geothermal gradient. Normally, it would average about 1^{O}F. For every 100 feet of depth. Some areas are discharging heat at rates of 10 to 1,000 times normal. These are the areas of interest for development of geothermal energy.

The heat source that creates these near-surface "hot spots" is either:

(1) A deep-seated magma (molten rock) from which the heat escapes via faults, or

(2) A shallow magma or magma cooling chamber in areas of fairly recent volcanic activity (within the last few million years).

Groundwater is heated by these energy sources and rises toward the surface. In some places the hot water is trapped by overlying impermeable rocks. In others it reaches the surface through faults. Hot springs, fumaroles, mud pots and geysers are the surface expressions of such escape.

Geothermal Systems

Two types of geothermal systesms are considered to have present commercial application:

(1) Vapor-dominated systems (dry steam) are believed to contain both saturated steam and water in the reservoir. When a well is drilled, the decrease in pressure superheats and dries the steam. The steam may be used to drive a turbine directly. Vapor-dominated systems are believed to be relatively rare. Power production from such fields occurs at the Geysers in California; Lardarello, Italy; and Matsukawa, Japan. The Valles Caldera field in New Mexico appears to be of this type and is currently under development.

(2) Hot water systems are believed to result from a thermally driven convection system which moves the heated water upward. The upwelling hot water often penetrates the surface as hot springs, geysers, etc. When a well is drilled, a portion of the water flashes into steam and both water and steam come to the surface.

The steam is separated from the water and used to drive a turbine. Power production from hot water fields is currently underway at Wairakei, New Zealand; Otaka, Japan; Cerro Prieto, Mexico, and Pathe, Mexico.

U.S. Geothermal Developemnt

The Geysers, in northern California, is the only commercially developed geothermal energy field in the United States, with the exception of local use for space heating in a number of places.

At the Geysers, five power generating plants operate on a vapor dominated geothermal system to produce 400 megawatts of electrical power. This is roughly equivalent of 2/3 the electrical power demand of the City of San Francisco. The ultimate capacity of the field, when fully developed, is estimated to be between 1,000 and 3,000 megawatts--sufficient power to satisfy the demands of the entire San Francisco Bay urban area.

The initial development at the Geysers was pioneered by Magma Power Company. Union Oil Company is the current operator.

Exploration has been going on for the last 15 years or so in many localities in the western States. Technical development problems and the economics of alternate fuel sources have thus far delayed commercial power development.

Oregon, California, and Nevada Geothermal Development.

Between 600 and 800 hot springs are scattered over the three states - evidence of higher than normal heat flow in many areas. During the 1800's and early 1900's resorts grew up around many of the hot springs.

Shallow wells, drilled into hot water systems, are currently used for space heating in all three states. At the Geysers, in California, geothermal steam is used to drive turbines and generate electricity.

Only in the last several years have serious attempts been made to develop geothermal energy within the three states for the generation of electricity. Most of the exploration effort has been made by Magma Power Company, which has drilled more wells throughout the three states than all the other geothermal companies combined. Magma Power Company has drilled exploratory holes on almost all the best geothermal areas in the three states.

South Central Oregon, Northeastern California, and Northwestern Nevada Geology and Mineral Development

(A) Geology -- South central Oregon, northeastern California, and northwestern Nevada are within the northern extension of the "Basin and Range Province". The topography consists of broad, flat basins separated by plateaus or fault block mountains. The basins are separated from the uplands by long north-south and northwest-southeast trending scarps. The scarps are caused by high angle normal faults with large vertical displacements.

Most of the rocks in the area are Tertiary age volcanic, intrusive, and sedimentary rocks, which are best exposed on the fault scarps between the basins and uplands. Pre-Tertiary rocks are not exposed in this area, but they are believed to be Mesozoic sedimentary rocks. The other rocks in the area are Quarternery age sediments and volcanic rocks.

The volcanic rocks are flows, breccias, agglomerates, eruptives, tuffs, and ash-flow tuffs. The flows, breccias, eruptives, and tuffs range in composition from basalt, andesite, and trachyte to dacite, rhyodacite, and rhyolite. The ash-flow tuffs are either rhyolitic or dacitic, and the agglomerates are basaltic.

The intrusive rocks form dikes, domes, breccias, necks, plugs, and sills. The plugs and domes consist of rhyolite and dacite, and sills and necks consist of andesite, basalt, and gabbro. The dikes and breccias range from rhyolite and dacite to andesite and basalt.

The sediments are gravel, sand, silt, clay, evaporite, and talus.

There has been seismic activity in the area as recently as 1968. The earthquake epicenters, just south of Crump Lake in the Warner Valley, averaged 4.9 on the Richter Magnitude Scale.

(B) Mineral Occurrences -- The U.S. Geological Survey states that the entire area is prospectively valuable for oil and gas. The oil and gas is supposedly in the Mesozoic basement rocks, although no exploratory wells have been drilled deep enough to confirm this.

Diatomite and some sodium and potassium in evaporites are present in a few basins and playa lakes. Because there has been no attempt to mine the diatomite or evaporites in the area, the deposits must be either too low grade or too poor a quality to be economic.

The Lone Pine Mining District, south of the Sheldon Antelope Refuge in Nevada, has had some small scale mining for mercury, but it is presently inactive. There are no figures on the production from the district.

There are other mercury occurrences in the area, but they are only prospects.

The only active mining in the area is common variety materials for road maintenance and construction. The materials being mined are cinders, gravel, sand, and rock (basalt and andesite).

(C) Geothermal Energy Development -- Hot springs are abundant throughout this area of Oregon, California, and Nevada. Since the early 1900's, hot water from wells in the Klamath Falls vicinity has been used for space heating, hot baths, and swimming pools. Several other places throughout the area are now utilizing hot water in the same way.

Exploratory drilling for geothermal steam was begun in 1959 by Magma Power Company. Since the, the U.S.G.S., the Oregon Department of Geology and Mineral Industries, and other companies have done some exploration and test drilling in the area.

The recent investigations consist of geologic mapping, water sampling, gravity and resistivity surveys, shallow drilling with thermal gradient and heat flow measurements, and deep exploratory drilling.

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Stages of Implementation

Four separate stages of implementation have been identified:

I. Exploration
II. Development
III. Operation
IV. Close-out

The progression from one stage to the next is dependent upon the success of each earlier stage. In practice, one stage often blends into another and it would be common for exploration and development to be undertaken in one part of a geothermal field, while a production operation was going on in another part of the field. Close-out of some wells, including rehabitation, might also be taking place at the same time.

EXPLORATION

Exploration includes all activities from the decision to explore for a geothermal field through the drilling of one or more "wildcat" (exploratory) wells.

Operations conducted under an approved "Notice of Intent to Conduct Geothermal Resource Exploration Operations", (43 CFR 3209) cover any surface disturbing techniques up to and including the drilling of shallow temperature gradient holes. Such operations do not include, however, the drilling of core holes for geologic information nor the drilling of "wildcat" geothermal wells.

Operations conducted under a geothermal lease (both competitive and noncompetitive) include all exploration actions.

For convenience, exploration activities (as they relate to surface damage) may be classified into five discrete operations, four of which require physical presence of the land. They are:

(A) Airborne exploration
(B) Off-road vehicular travel
(C) Road and trail construction
(D) Drilling
(E) Rehabilitation

In practice, several of these operations may be going on concurrently. The technique is to start by evaluating large areas (i.e. several townships) and gradually reduce the area of interest to select a target for drilling. As the area of interest shrinks, more intensive exploration techniques are employed.

(A) Airborne Exploration - This involves a series of techniques including:

(1) Aerial photography - for geologic interpretation.
(2) Imagery - infared to detect heat differentials; microwave to detect soil moisture differentials.
(3) Magnetic - airborne magnetometer measures variations in the magnetic intensity of the earth.
(4) Gravity - airborne gravimeter measures differences in the specific gravity of the earth.

All of these techniques are attempts to gain data on the subsurface geology of an area. The data gathered must be interpreted by specialists and may supply clues as to areas deserving of more detailed studies.

Airborne exploration produces no surface disturbance. It creates only a temporary negligible impact on air quality and noise levels.

(B) Off-Road Vehicular Travel - Many exploration techniques require off-road vehicular travel in various degrees. Generally, existing roads are used where possible. Techniques which sometimes require cross-country travel include:

(1) Geological mapping - One or more small vehicles transport geologist to the work area

(2) Geophysical exploration - Includes a number of techniques seeking clues as to underground geology:

Gravity - Ground gravity surveys involve obtaining gravity readings along a surveyed grid with a portable gravimeter. A three-man crew does the work (two survey and the third records gravity reading). One or two small trucks transport the crew and equipment to the work area.

Magnetic _ Magnetic variations are measured with a magnetometer. The field technique is similar to the gravity determination.

Seismic - Elastic shock waves are generated and measured along a grid system (generally 1-2 mile grid). Receivers (geophones) pick up elastic waves generated at a specific point on the grid. The elastic waves are generated by one of three methods:

Vibration method - Vibrations are produced by truck mounted vibrators, usually four, which operate in unison.

Thumping method - A truch-drawn or self-propelled unit containing a heavy weight or "hammer" drops the hammer on the ground to produce shock waves.

Explosive method - A truck-mounted rotary drill is used to drill holes 100-200 feet deep. These holes are loaded with 5-50 lbs. of explosives and detonated (shot) to produce the elastic waves.

In all three seismic methods, 5-7 trucks and 10-15 men are required. Surface mineral matter and vegetation must be removed from the energy generation sites (shot points) and receiving sites (geophones) to provide for the maximum amount of energy to be sent and received. In addition, the explosive method often requires road construction, blading of lines and clearing of small areas for drill operation.

All three seismic methods involve varying degrees of surface disturbance. The explosive method produces the most intense surface disturbance. Only the explosive method possesses the potential for subsurface impact (damage to nearby water wells, damage to near-surface aquifers, etc.), and then only within a limited radius of the shot point.

Microseismic - Small geophones called seismometers are buried at a shallow depth and transmit normal extremely minor seismic activity (micro-earthquakes) to an amplifier on the surface. The amplifier is about the size of a suitcase. Locations are set up away from roads to avoid traffic "noise". These units are often backpacked into areas inaccessible to vehicles.

Resistivity - Induced Polarization (IP) techniques are used to measure the resistance of subsurface rocks to the passage of an electrical current. A vehicle mounted transmitter sends pulses of electrical current into the ground through two widely spaced electrodes (usually about two miles apart). The behavior of these electrical pulses as they travel through underlying rocks is recorded by "pots" (potential electrodes), small ceramic devices that receive the current at different locations. The electrodes are either short (2-3 feet) rods driven into the ground or aluminum foil shallowly buried over an area of several square feet. Two or three small trucks transport the crew of 3 to 5 men to transmitting and receiving sites.

Telluric - A string of "pots" (potential electrodes) record the variations in the natural electrical currents in the earth. No transmitter is required. Small trucks are used to transport the crew to the work area.

Radiometric - Radioactive emissions (generally radon gas) are measured as an indication of subsurface steam. Such measurements are usually made in the vicinity of hot springs, hence existing roads are generally used. Measurements are taken with a hand held scintillometer.

(3) Geochemical surveys - Includes the sampling of spring water to determine dissolved solid content (acidity, Na/K ratio and silica content) and the taking of small (hand trowel) surface mineralization and source areas for recharge. Occasionally small trucks are used to transport the crew (usually 2-3 men) and equipment to the work area.

(C) Road and Trail Construction - For exploration activities utilizing large equipment in rough terrain with poorly developed access, roads and trails are often constructed. Since they are intended to provide only temporary access for such equipment as small drilling rigs and water trucks, they are usually constructed to a very low standard--generally a 10-foot wide dozer trail is used in dry, stable country. Where larger drilling equipment is to be used for an exploratory (wildcat) well, a considerably higher road standard may be employed.

(D) Drilling - Several types of drilling are utilized in the exploration phase including seismic test holes, temperature gradient holes, geologic or stratigraphic information holes, and exploration wells. The size of the equipment and the surface area needed differs with each. The type of drilling used is rotary drilling which employs the principle of a rotating vertical pipe (drill stem) upon which has been mounted a rock bit designed to chip rock as it rotates under pressure.

Drill cuttings or chips produced as the hole progresses are removed from shallow shot-holes by introducing a jet of air during drilling. For deeper drilling, a circulating medium of water or mud (a suspension in oil or water of various finely-divided substances, each possessing specific properties) is pumped down the inside of the drill pipe and allowed to return up the annular space between the hole wall and outside of the drill pipe. This circulating medium is used to cool and lubricate the bit as well as to return the drill cuttings to the surface. Drilling mud helps prevent caving by plastering and consolidating the walls of the hole with a clay lining, thereby making casing unnecessary during shallow drilling.

(1) Seismic test holes - Shallow holes 100-200 feet deep are drilled with small truck-mounted rigs. Cuttings are removed by compressed air. The surface area used is just sufficient for the truck and equipment. An area of about 30 x 30 feet is disturbed by the operation. No specific drill pad is built.

(2) Temperature gradient holes - Shallow holes 300-500 feet deep are drilled with a small truck-mounted rig. The holes are usually between 4 and 6 inches in diameter. Mud is employed to remove the cuttings, and generally a portable metal mud pit is used to contain the mud. An area of about 30 x 30 feet is disturbed by use of the drill rig and servicing water truck.

Upon completion of the temperature gradient hole a capped pipe (usually 3/4 inch diameter) is placed in the hole, and let stand for about a week. Water in the pipe is heated by the temperature of the surrounding rock. Because of the small diameter of the pipe, convection currents do not form, hence the water temperature in the pipe varies with depth. The temperature at different depths is measured by a thermister probe on a cable.

(3) Geologic information holes - These are similar to those drilled for temperature gradient purposes. Larger equipment is employed and a surface area of about 40 x 60 feet may be used. The cuttings are examined and the hole is probed with geophysical instruments to acquire data on the rock types and structure. Because these holes may extend to 1000 feet or more, a larger mud pit is needed. Typically, a mud pit is scooped out with a bulldozer. These pits may be 10-20 feet wide by 30-50 feet long by 3-6 feet deep depending on the terrain and the depth of the hole.

(4) Exploration wells - These wells are the same as development and production wells. If successful, they are generally converted to production. Drilling equipment, technology and methods are similar to those used in oil and gas operations. Well bores of up to 24 inches in diameter may be drilled to depths of 5,000-10,000 feet.

Mud is generally used for the drilling. Where water flows are not encountered, compressed air may be substituted as the circulation medium. At the Geysers dry steam field, for example, mud is used to the depth that temperature interferes with proper operations, then compressed air is used. Noise created during the air drilling operation is intense and approximates that of an unmuffled diesel truck.

A drill pad is leveled and cleared of vegetation. This generally involves a surface area of from less than one acre up to two acres. The ancillary equipment is generally also located on the drill pad. A reserve pit of approximately 1,000 to 10,000 square feet and 6-8 feet deep is sometimes dug to contain waste fluids and drill cuttings during drilling operations.

The well is cemented and cased and a blow-out preventer is installed to control sudden surges of pressure.

Blow-outs are uncommon, but do occur. The basic problem is a lack of knowledge of the specific characteristics of a geothermal field. During the pioneering development in many fields around the world, blow-outs seem to have occurred in 1-3% of the test and production wells drilled. At the Geysers there have been three blow-outs with over 100 wells drilled. Landslides in that steep terrain caused much of the problem. Geothermal blow-outs cause no fire hazard and are generally controlled by slant drilling and sealing with concrete.

While the blow-out is taking place, water, steam and contained elements are wasted and spread on the surrounding land.

The release of pressure and water through drill holes may affect the surface expression of the geothermal field. Springs and geysers may dry up, may be renewed in a different place, or may be increased. Accurate prediction of the results of drilling on such surface features cannot be made.

Since geothermal reservoirs are typically in active fault areas, normal earthquakes also occasionally change the surface features by drying up, moving or increasing thermal activity. It is thus not always possible to determine whether the observed effect was caused by drilling or by natural action.

(E) Rehabilitation - Rehabilitation activities vary with terrain, climate, and significance of the damage.

(1) Off-road vehicular travel. Generally no rehabilitation is undertaken because the disturbance is temporary and, in most areas, heals itself in a short time.

(2) Road and trail construction. Generally no rehabilitation is undertaken unless there is a definite requirement for it (i.e. erosion hazard, access where none is wanted, etc.). Where needed, such roads and trails can be scarified and reseeded if the site is susceptible to revegetation.

(3) Drilling. Small drill hole sites (seismic test holes, temperature gradient holes, informational holes) are usually rehabilitated by cleaning up any debris and smoothing the area with a bulldozer where needed. Mud pits are filled and leveled. Where climate and terrain permit, revegetation could be accomplished.

Large exploratory wells are capped with a pressure head ("Christmas tree") to prevent blow-outs, and typically left in operating condition. Other structures are removed and the drilling pad may be revegetated if climate permits.

DEVELOPMENT

Development includes all activities from the decision to develop a producing field until commercial power generation and transmission is reached. These operations are conducted only under a geothermal lease (either competitive or noncompetitive).

Five discrete operations, as they relate to surface disturbance, are recognized:

(A) Road development
(B) Drill site development
(C) Geothermal pipelines
(D) Plant construction
(E) Transmission lines
(F) Rehabilitation

Many of these operations would normally be taking place concurrently.

(A) Road Development

During development, roads to drill sites, power plant sites, and along transmission line routes may be constructed. Roads to producing wells and power plants will be permanent and may be surfaced and stabilized. Culverts will be utilized to avoid erosion of the road bed where necessary. Temporary roads to drill sites and for construction of power lines will generally be built to a low standard.

(B) Drill Site Development

Wells drilled during the development stage will be similar to exploration wells. Often, somewhat larger equipment is used. The drill pad is leveled and cleared of vegetation. Generally from less than one up to two acres are disturbed. A reserve pit (sump) 1,000 to 10,000 square feet and 6-8 feet deep is sometimes dug to contain waste fluids during the drilling operations. The sump may be fenced to keep out animals.

(1) Water - About 500-1,000 barrels (1 barrel = 42 gallons) of water per day will be used in drilling a well. This water may come from water wells drilled in the immediate vicinity (about 60 gpm flow would be adequate), from nearby surface water, or it may be hauled in by truck.

(2) Spacing - Current geothermal plants require a steam pressure of about 100 PSI at the generator. This places a limit on the distance steam can be piped to the generator because of heat loss. Wells are therefore generally located within one-half

mile of the generation plant. The number of wells used to service a plant is dependent on the temperature of the wells (a temperature of 325-350^{o}F at the generator is needed) and the characteristics of the geothermal reservoir. Generally, from 16 to 20 producing wells are used per power plant.

At Cerro Prieto, 18 wells (3 are standby) will service a 75 MW generating plant. They are drilled on a 10 acre spacing (one well per 10 acres). A 40 acre well spacing is being used at the Geysers initially, but future infill drilling to 20 acre spacing is planned in order to maintain steam production to plant capacity.

(3) Production Testing - To determine the sustained flow characteristics of a well, and to clean out the hole, each new well is vented to the atmosphere for a period of time. At the Geysers, enough experience has been gained as to the characteristics of the reservoir that this is no longer necessary there. Elsewhere it is an established practice.

Steam, water, and noise accompany production testing. The water is generally directed into the reserve pit and is contained. The steam is released into the atmosphere.

Noncondensible gases (carbon dioxide, methane, hydrogen, nitrogen, argon, carbon monoxide, hydrogen sulfide, radon, ammonia) and vapors (boric acid and mercury) are often contained in the steam. These vapors and gases make up generally less than 3% of the total steam fraction.

When present in excessive amounts, some of these gases and vapors are toxic.

Gas	Toxicity Levels
Ammonia	50 ppm
Boric acid	None established
Carbon dioxide	5,000 ppm
Carbon monoxide	100 ppm
Hydrogen sulfide	20 ppm
Mercury	12.2 ppb
Methane	10,000 ppm

Where present in unacceptable amounts, monitoring devices and special precautions may be necessary as a safety measure.

Additionally, very small amounts of hydrogen sulfide (as small as .025 ppm) can be detected by smell. This "rotten egg" odor, common in hot spring areas, can be an aesthetic problem.

High noise levels accompany production testing. Because of this, muffling devices are generally installed. At the Geysers measurements of noise from a muffled testing well indicates a noise level slightly less than that of an unmuffled diesel truck.

Noise levels from other geothermal fields, both vapor dominated and water dominated, may not be of a similar magnitude.

(4) Blowouts - In the four geothermal areas in the world (Geysers, USA; Lardarello, Italy; Wairakei, New Zealand; Cerro Prieto, Mexico) which have undergone commercial development, blowouts have occurred in approximately 1-3% of the wells drilled. These blowouts were mostly in the exploratory or early stages of development drilling, with few mishaps in later stages as experience was gained and local drilling techniques perfected. Although some of these blowouts were temporarily spectacular, none have resulted in any significant or lasting environmental damage.

At Lardarello, Italy, the oldest commercial geothermal field in the world, they are routinely handled as a noisy, difficult, part of regular operations. They are not considered as serious mishaps that could cause pollution or have other adverse effects.

(C) Geothermal Pipelines

Pipelines 10 to 30 inches in diameter will be used to transmit steam or hot water from the production wells to the power plants. The pipes are typically insulated with fiberglass or asbestos to minimize heat loss. Expansion loops or joints are placed at frequent intervals either vertically or horizontally to provide for the extreme expansion and contraction of the pipes upon production startup (heating up) and shutdown (cooling down).

Under present technology, pipelines are constructed above ground to provide for expansion and contraction and to enhance maintenance and detection of leaks. Underground installation is thus far uneconomical and may also present some safety hazards.

The lines form a radiating pattern on the surface, connecting wells with the power plant. They may be painted to blend with the surroundings.

(D) Plant Construction

Generating plants are centrally located to minimize the length of the steam or water pipes from the servicing wells. The largest plants in current use consist of two 55 MW generators housed together so that production is 110 MW per power plant. Power plant spacing is about one plant per 640 acres throughout the productive area.

At the Geysers, the average 110 MW plant building is about 100 x 200 feet and three stories high. The adjacent colling towers are about a third larger than the generating plant building. The entire generating plant-cooling tower complex occupies an area of about five acres.

(E) Transmission Lines

Power generated from the plant is transmitted via conventional power lines to the area of use. The size and location of the lines is dependent upon the power output and destination.

The lines will tend to be large, considering that 1 MW of plant capacity will service the power needs of about 1,000 people. To express this another way, one 110 MW power plant could supply the power needs of the City of Reno.

(F) Rehabilitation

Rehabilitation will be possible on disturbed areas not needed for continued production, commensurate with terrain, climate and significance of the damage.

(1) Road Development - Roads needed for maintenance and further development will not be rehabilitated. Temporary roads and trails can be scarified and revegetated, if desirable.

(2) Drill Site Development - After well completion, an area approximately 30 ft. x 30 ft. directly surrounding the well head will be needed for operation. An additional graded area about 50 x 100 feet may be needed for moving in a drilling rig to correct any problems which may develop during production. THe reserve pit (sump) is generally dried out, covered with dirt, and graded. It and the remaining area of the drill site can be rehabilitated and revegetated.

(3) Plant Construction - The area disturbed in constructing the generating plant and cooling towers can be rehabilitated and revegetated. The buildings may be painted to blend with the

surroundings. Some cooling towers are architecturally attractive and, if desired, may be intentionally painted to contrast with the surroundings to heighten the visual experience.

(4) Geothermal Pipelines - Geothermal pipelines may be painted to blend with the surroundings and any areas not needed for access may be revegetated. At Lardarello, Italy, steam lines cross grainfields and vineyards with essentially no loss of land productivity.

(5) Transmission Lines - Surface disturbance accompanying electrical transmission line construction may be rehabilitated with the exception of needed maintenance roads.

OPERATION

The operation phase starts upon reaching commercial power production. Exploration and development are typically carried on in other parts of the geothermal field simultaneously with the operational activities.

The operation stage may be divided into the following discrete operations:

(A) New drill sites
(B) Maintenance
(C) Waste disposal
(D) Production

(A) New Drill Sites

Geothermal fields are long lived resources. The Lardarello field has been in production since 1904 and the Geysers since 1958. The Geysers is estimated to have a minimum productive life of 30 more years. Nonetheless, production slowly diminishes the heat flow and additional wells must be drilled and completed to keep the generating plant operating at full capacity.

Additional wells may also be required to replace wells that have become inoperative and, if the waste waters are disposed of by injection, injection wells may be drilled.

The technique and effect of these wells would be the same as for development wells. On a major producing field, it can be expected that one or two drilling rigs would be operating continuously throughout the life of the field drilling additional or replacement wells.

(B) Maintenance

Repair, maintenance, and monitoring of an operating field will require the periodic use of access roads to service the equipment. Existing wells will require occasional repair work or cleanout. The amount of this remedial work will depend upon the production characteristics of the field; severe scaling and corrosion would require frequent remedial work. Normally one medium-sized drill rig would be required full-time for each 20-30 wells (one 110 MW power plant).

(C) Waste Disposal

The work force (both construction and maintenance) for geothermal power plants will usually be housed in the nearest town rather than creating a new town at the site. Thus, waste materials connected with human habitation will typically be handled in the local community.

At the plant site itself, sanitary facilities for workers will be provided. Solid wastes will either be disposed of in a dump developed at the site or trucked to the nearest established dump site.

The most significant waste disposal problem relates to handling the excess geothermal fluids. In vapor dominated systems, as at the Geysers, about 75-80% of the water from the spent steam is consumed in the cooling towers, leaving 20-25% to be disposed of. In water dominated systems, such as Cerro Prieto, the reverse is true with 80% or more of the total well production requiring disposal.

Disposal techniques vary, depending on the quality and quantities involved. Any or a combination of the following techniques may be employed:

(1) Evaporation ponds - Waste water at Cerro Prieto is piped to evaporation ponds. Where water quality is satisfactory, such ponds may provide new aquatic habitat. Where water quality is toxic, special measures may be required to protect the groundwater supply, livestock, and wildlife.

(2) Natural drainage systems - At Wairakei, New Zealand, waste water is discharged into a large river. High quality water disposed of in this manner provides additional resources for agriculture, wildlife and other uses. Low quality water may require extensive treatment before it is suitable for release into natural drainages.

(3) By-product development - In some instances it may be economical to extract useful minerals or gases from the geothermal fluids. This could result in increasing the waste water quality so as to make it available for other purposes. Desalinization may also be feasible in some areas, providing by-product fresh water for other uses.

(4) Re-injection - At the Geysers, excess water is re-injected into nonproductive zones of the geothermal field. Successful re-injection is dependent on the quality of the waste water and the geologic characteristics of the geothermal field. Typical considerations would include: whether plugging and scaling problems will prevent the reservoir from accepting the fluid; whether fresh water aquifers can be adequately protected from contamination by hot saline waste water; and whether the subsurface rock structure will adequately hold the re-injected fluids.

(D) Production

Production from a geothermal field will generally require 2-5 people per plant to inspect, adjust and service the wells, making the rounds about once each day on the existing road network.

Sustained production will have several effects:

(1) Temperature drop - The field will gradually realize diminishing temperatures as the energy is utilized.

(2) Water utilization - Cooling towers will consume about 40-45 acre feet of water per year for each megawatt of plant capacity. Each 110 MW plant would thus consume about 5,000 acre feet of water per year. The water may come either from steam condensate, waste geothermal water, or from any other water source. This water consumption might be reduced by use of some technique other than conventional cooling towers. One such scheme, called the "night stream cooling system" would theoretically use only 42% as much water.

(3) Subsidence - As large volumes of water are pumped from a geothermal reservoir, some subsidence of the ground surface may occur. In many cases subsidence may have no serious land use or environmental consequences. In some situations, such as developed agricultural land under gravity irrigation, minor surface subsidence could have a significant impact. Continuous monitoring might be necessary to detect whether subsidence was occurring. In some instances, re-injection of the waste water might correct subsidence problems.

(4) Seismic activity - Geothermal areas are typically associated with seismic activity. Such activity is generally of small magnitude (usually less than 4.5 on the Richter scale). Fluid pressure changes from both production and re-injection may tend to increase earthquake frequency, though the relationship is not well known. To date, such earthquakes have been small and there is some evidence to suggest that this minor seismic activity tends to relieve regional stresses and diminishes the likelihood of large earthquakes. Earthquakes sometimes modify geyser activity and may effect other geothermal features such as hot springs.

CLOSE-OUT

Close-out or final abandonment takes place when energy production ceases to be economic. To date, no developed geothermal field has reached this stage. In a sense, geothermal reservoirs may be somewhat renewable resources in that after a long period of rest, the fluids may become reheated to temperatures that are again useable.

Two discrete operations are expected to take place during close-out:

(A) Removal of improvements
(B) Restoration of surface

(A) Removal of Improvements

The removal of improvements from a geothermal field involves:

(1) Surface improvements - Removal of all structures constructed during field development and operations will be accomplished. Solid waste remaining may either be disposed of in a dump developed at the site or trucked to the nearest established dump.

(2) Wells - The bottom of the hole is plugged with cement and the surface casing will also be plugged with about 20 feet of cement. The casing will be cut off below the surface and a steel plate welded over the hole. A vertical steep pipe and marker will be welded to the plate. The concrete lined excavation surrounding the hole (called the "cellar") will be pushed in and the location may be graded and revegetated. The marker will remain above ground to provide identification.

(3) Transmission lines - Any of the electrical transmission lines no longer in use will be removed.

(B) Restoration of the Surface

Surface restoration will typically be a gradual process, taking place throughout the life of the field and culminating with the final abandonment. Access roads can be ripped up, landscaped and revegetated. Power lines can be landscaped and revegetated. Well and plant locations can similarly be treated but, becuase of their large size, complete landscaping to approximate the original surface in steep terrain will not be feasible except in unusual circumstances.

Environmental Controls

Geothermal energy development is subject to a wide variety of environmental controls under the authorities of two agencies--Geological Survey and BLM. Such environmental controls are covered in the regulations of both agencies (GS - 30 CFR 270; BLM - 43 CFR 3200) and are part of the exploration form (3200-9) and lease form (3200-21). Additional controls in the form of special stipulations, geothermal resources operational orders (GRO orders), and approved operational plans may also be used. Bonding is required to assure compliance.

Basically, the two agencies consult throughout the leasing program and agree on any needed special stipulations. For all actions up to and including issuance of a lease, the BLM is the responsible agency. For all operational activities undertaken after a lease has been issued, the Geological Survey is the responsible agency.

Opportunities to attach special environmental controls occur at several points:

(A) Notice of Intent To Conduct Geothermal Resource Explorations - (Form 3200-9) - This form is filed for exploration activities not connected with a lease. The BLM District Manager has 30 days to either approve or disapprove the permit. Special stipulations may be added if needed. The Geological Survey will advise of any recommended stipulations to protect subsurface resource values. A $5,000 compliance bond is required.

(B) Proposed Plan - Prior to the issuance of a lease, the applicant must file a proposed plan detailing his proposed methods for diligent exploration. Environment protection measures proposed are included. The irproposed plan may alert the District Manager to special problems that should be covered by special stipulations in the lease. The Geological Survey will also review these plans and may furnish additional comments or information which may be useful for environmental considerations.

However, these proposed plans are filed so early in the process that they will generally be based on little knowledge of the available geothermal resource and, hence, will usually undergo major changes as new exploration data is gathered. The will tend to be written in broad general terms commensurate with the limited data available. Therefore, they cannot be entirely relied upon in anticipating

environmental effects.

The chief value of the proposed plan is to commit the applicant to a program of diligent exploration. Reliable environmental judgements can be made later when an actual plan of operation is filed.

(C) Leases - Lessees are committed to a variety of environmental controls by regulation and the standard lease (Form 3200-21) contains stipulations on protection of the environment and antiquities.

Additionally, special stipulations may be added if necessary. The Geological Survey will provide advice as to recommended special stipulations to protect the subsurface environment and as to the effect of any proposed BLM special stipulations on geothermal development.

Two bonds are required: a $10,000 bond to insure lease compliance, and a $5,000 bond to indemnify any damages to persons or property. A $150,000 nationwide bond or $50,000 Statewide bond may be substituted.

(D) Geothermal Resources Operational Order (GRO Order) - The Geological Survey issues GRO orders which set forth the requirements and procedures to be followed within a particular region or area. This allows flexibility to address conditions which vary widely from area to area. The BLM District will be consulted by Geological Survey to develop any needed surface resource protection requirements.

(E) Plan of Operation - Before any operations may commence on a lease, the lessee must submit a detailed plan of operation and gain approval of it. Both the Geological Survey and the BLM must approve it.

In practice, these plans will tend to be incremental with new phases of the plan based on information gained in the preceding phase. They will be detailed enough to allow a sound environmental assessment prior to approval.

Energy Considerations

U.S. energy demand is expected to continue increasing at a rate of 3-5% per year. To keep pace, we shall either have to import more fuel (imports are currently about 4%) or develop more domestic sources. Former President Nixon stated that our policy goal is to become independent in energy resources by 1980.

All forms of energy supplement one another in the total energy picture. Should geothermal energy be used to produce electricity, other forms of energy (coal, oil, gas) would be freed for use elsewhere.

Estimates of our geothermal potential vary widely but suggest that by the year 2000 such energy may supply 5-14% of our use. This is a significant amount considering that hydroelectric power currently supplies only about 5% of the total.

Geothermal energy offers less environmental impact than conventional energy sources. Essentially all of the impact, with the exception of power lines, is confined to a small site. Other power forms have multiple impacts: power dams flood large acreages; coal, oil, gas, and nuclear sources are mined in one place, transported to another place where power is generated and then transmitted via power lines to the area of use.

In the short range, geothermal sources stand a far better likelihood of substantial contributions to the energy pool than do such exotic sources as solar energy, breeder and fusion reactors, fuel cells, etc.

Economic Considerations

There are several ways to view the economic implications of geothermal development:

(A) Direct revenues
(B) Indirect revenues
(C) Direct expenditures
(D) Indirect expenditures

(A) Direct Revenues

Lease rentals and royalties are distributed as follows:

95% - U.S. Government
5% - State Governments

(1) Rentals - Each lease brings in $1/acre per year annual rental (minimum) which increases on a graduated basis after the fifth year. Advance rentals filed during the first three months of filing in Nevada total 1.7 million dollars.

(2) Royalties - When production is reached, royalties of 10-15% of the value of the steam are assessed. Royalties up to 5% are also paid on by-product minerals, including commercial demineralized water.

At the Geysers, a royalty of 10% of the steam value is paid to private landowners. The royalty averages about $250,000 per year per 100 MW plant. With 400 MW capacity, the royalty is about 1 million dollars per year from a production area about two miles wide by seven miles long.

(3) Bonus Bids - On competitive lease sales, bonus bids are an additional source or revenue. In the first federal lease sale held in California on January 22, 1974, twenty leasing units were bid on with 57 bids totalling $12-½ million. The highest bid for a single leasing unit was $3,200,000, which amounts to $1,367.50 per acre for the 2,340 acre unit.

(B) Indirect Revenues

Taxation by State and local subdivisions accounts for an additional increment of revenue. Taxes paid to Sonoma Co. from the Geysers approximate $1 million per year for the current 400 MW capacity.

Dr. Robert W. Rex, President of Republic Geothermal Inc., in remarks to the Sub-Committee on Energy, Committee on Science and Astronautics, U.S. House of Reporesentatives, on September 18, 1973, said in part "...Every 1000 megawatts of geothermal development on Federal lands yield about $1 billion of public revenue; 73% to the Federal government, 11% to State governments which have income taxes...and 18% to County governments.

(C) Direct Expenditures

Development of a 110 MW plant costs $15-17.5 million at the Geysers. Individual wells cost about $150,000-$200,000 each.

(D) Indirect Expenditures

The local business community will be affected by geothermal development, both by increased business and by having to provide additional services.

During exploration drilling, two drilling rigs might be used for 1-2 years. Employees would consist of about 40 people directly involved in drilling, with 10-20 additional service people intermittently involved.

Development would advance in 55-110 MW increments in an orderly fashion over a period of 2-10 years. Drill crews for 2-3 rigs would number 40-60, and 20-30 additional people would be involved in plant construction. All of the above personnel would be temporary.

Once the field is operating on stream, about five (5) permanent employees are needed for field production plus five (5) more for each 110 MW plant. One drilling rig would be needed full time, adding 20 more permanent employees to the area.

Thus, for several years, a local community would be burdened with providing necessary school and service facilities for between 40 and 90 additional temporary families. Thereafter, 30 or more families would become permanent residents, also requiring services.

In the short run, communities near a geothermal development would be financially strained. However, such development is capital intensive and in a few years the increased tax base should be much greater than community expenditure on a per capita basis of additional residents.

Other Considerations

This technical report is addressed principally to electrical power generation from vapor dominated and hot water geothermal systems. There are other uses and other geothermal systems that might be involved.

(A) Uses - The heat from geothermal fields may be used for space heating, greenhouse heating, vegetable dehydration and a myriad of other uses for which a heat source is required. Water also might be used for a variety of purposes. The impacts of these uses would be less than the impacts of power generation.

(B) Systems - The hot water and steam systems offer the best chance of commercial use in the near future. For long range consideration two other systems may, with developing technology, become useful.

(1) Hot Dry Rock Systems - Basically similar in origin to the water or steam systems, but lack water to form a convection cell. Such areas may be susceptible to fracturing and introduction of water to develop steam for power generation. Exploration of what is believed to be a hot dry rock geothermal area is currently being carried out on National Resource lands near Marysville, Montana by Battelle Northwest Institute under a National Science Foundation grant.

(2) Geopressurized Reservoir Systems - Consist of hot brines under great pressure in marine sediments along the Gulf Coast. They are thought to represent an accumulation of heat due to the normal heat flow being trapped by an insulating layer of under-compacted clay. The resource is large, but years will be required to develop the technology for commercial use.

Stipulations

To be effective, stipulations must be feasible, understandable, germane (related to a specific problem), not redundant, and enforceable.

(A) General Stipulations - The regulations and the standard lease form contain stipulations that cover most general environmental problems. They require among other things, that the lessee shall comply with all Federal and State pollution standards (air, land, water, and noise) and that the lessee shall take all mitigating actions required by the lessor to protect the environment and to restore any lands affected by the operation.

(B) Special Lease Stipulations - Care must be taken to avoid using special stipulations that reiterate general stipulations already covered. Special stipulations should relate to specific lease conditions that will have a significant operational or economic impact on the lessee. Generally, these will involve:

(1) Restrictions on surface occupancy.

(2) Restrictions on time of year when operations will be permitted.

More detailed stipulations can best be developed during the operational stage.

(C) Plan of Operation Stipulations - Detailed stipulations such as erosion control, road and drill site locations and standards, surface facilities, restoration requirements, etc. are developed when the plan of operation is being reviewed. The plan provides the detailed information on operations, location, and methods, that allows the development of specific, enforceable stipulations tailored to that plan.

(D) Technical Problems With Stipulations - Some stipulations that would appear to provide improved surface protection may face economic or technical restrictions that are not initially apparent.

For example, directional drilling would lessen surface damage. However, it can add from $20,000 to $100,000 extra cost per hole (depending on the angle). Also, directional work in hot holes presents special problems in getting surveys to accurately locate the bottom of the hole as most survey systems involve photographic film which is severely affected by the heat.

In addition, directional drilling may pose a significantly greater safety hazard. The extreme temperature differences from drilling to producing conditions (often 400°F or more) may create unsafe stress on casing. Stuck drill pipe is much more common in directional drilling. In hot holes, the greatest danger of blowouts occurs when mud temperatures exceed the boiling point-depth curve. Any excess down time without circulation, such as a stuck drill pipe, greatly increases the chances of a serious blowout due to the mud boiling off and blowing out of the hole.

Developing stipulations with technologic or economic implications must be closely coordinated with the Geological Survey to assure that such stipulations are sound.

Acknowledgments

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Sept. 3, 1974
Date

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Animals of Probable Occurance
within
the Klamath E.A.R. Area

MAMMALS - (entire E.A.R. Area)

Rocky Mountain Elk (Few)
Rocky Mountain Mule Deer
Black-tailed Deer
Pronghorn Antelope
Bobcat
Coyote
Mountain Lion (Cougar)
Racoon
Spotted Skunk
Striped Skunk
Badger
Red Fox
Mink
Long-tailed Weasel
Fisher
Ring-tailed Cat
Black Bear
River Otter
Beaver
Nutria
Muskrat
Yellow Bellied Marmot
Townsend Ground Squirrel
Belding Ground Squirrel
California Ground Squirrel
Least Chipmonk
Townsends Chipmonk
Yellow Pine Chipmonk
Chickaree
Western Grey Squirrel
Golden Mantel Ground Squirrel
Porcupine
Northern Pocket Gopher
Great Basin Pocket Mouse
Heerman's Kangaroo Rat
Western Harvest Mouse
Northern Grasshopper Mouse
Bushy-tailed Wood Rat
Pinyon Mouse
Deer Mouse
Brush Mouse
Long-tailed Meadow Mouse
Montane Vole
House Mouse
Norway Rat
Western Jumping Mouse
Water Shrew
Merriam's Shrew
Vagrant Shrew
Trowbridge Shrew
Broad-handed Mole
Mountain Cottontail
Snowshoe Hare
White-tailed Hare (Jackrabbit)
Black-tailed Jackrabbit
Pallid Bat
Lumpnose Bat
Silver Haired Bat
Hoary Bat
Big Brown Bat
Fringed Myotis Bat
Long-eared Myotis Bat
Hairy Winged Myotis Bat
California Myotis Bat
Yuma Myotis Bat
Little Brown Bat
Free-tailed Bat

Amphibians

Great Basin Spadefoot Toad
Western Toad
Pacific Tree Frog
Spotted Frog - (State Threatened List)

Reptiles

Short Horned Lizard
Western Skink
Sagebrush Lizard
Western Fence Lizard
Side-blotched Lizard
Rubber Boa
Racer
Striped Whipsnake
Gopher Snake
Common Garter Snake
Western Terrestrial Garter Snake
Western Rattlesnake

Birds

Pine Plateau

		Use Season				
Species	Population Level	W.	Sp.	S.	F.	Nesting
Mountain Quail	F	x	x	x	x	x
Blue Grouse	F	x	x	x	x	x
Mourning Dove	M	-	x	x	-	x
Goshawk	F	x	x	x	x	x
Sharp-shinned Hawk	F	x	x	x	x	x
Coopers Hawk	F	x	x	x	x	-
Golden Eagle	F	-	x	x	-	x
Bald Eagle	F	x	x	x	x	x
Osprey	F	-	x	x	x	x
Peregrine Falcon	F	-	x	x	-	M
Screech Owl	F	x	x	x	x	x
Great Horned Owl	F	x	x	x	x	x
Pygmy Owl	F	x	x	x	x	x
Great Gray Owl	R	x	x	x	x	x
Long Eared Owl	F	x	x	x	x	-
Saw-whet Owl	R	x	x	x	x	x
Turkey Vulture	F	-	x	x	x	x
Spotted Owl	R	x	x	x	x	x
Wood Duck	F	-	x	-	-	x
Hooded Merganser	F	-	x	-	-	x
Hairy Woodpecker	F	x	x	x	x	x
Downy Woodpecker	F	x	x	x	x	x
White-headed Woodpecker	F	x	x	x	x	x
Three-toed Woodpecker	F	x	x	x	x	x
Lewis Woodpecker	F	-	x	x	x	x
Flicker	F	x	x	x	x	x
Williamson Sapucker	F	-	x	x	x	x
Yellow-bellied Sapsucker	F	x	x	x	x	x
Western Bluebird	F	x	x	x	x	x
Mountain Bluebird	F	x	x	x	x	x
Violet-green Swallow	F	-	x	x	x	x
Purple Martin	F	-	x	x	x	x
Pigmy Nuthatch	F	x	x	x	x	x
Red-breasted Nuthatch	F	x	x	x	x	x
White-breasted Nuthatch	F	x	x	x	x	x
Brown Creeper	F	x	x	x	x	x
Red-tailed Hawk	F	-	x	x	x	x
Common Nighthawk	M	x	x	x	x	-
Rufus Hummingbird	F	-	x	x	x	x
Pileated Woodpecker	R	x	x	x	x	x
Dusky Flycatcher	F	-	-	x	-	x
Western Flycatcher	F	-	x	x	-	x

(cont.)

Species	Population Level	Use Season W.	Sp.	S.	F.	Nesting
Olive-sided Flycatcher	F	-	-	x	-	x
Western Wood Pewee	F	-	x	x	-	x
Gray Jay	F	x	x	x	x	x
Stellar's Jay	F	x	x	x	x	x
Common Raven	F	x	x	x	x	-
Pinion Jay	F	x	x	x	x	x
Clarkes Nutcraker	F	x	x	x	x	x
Mountain Chickadee	F	x	x	x	x	x
Chestnut-backed Chickadee	F	x	x	x	x	x
Canyon Wren	F	x	x	x	x	x
Robin	M	x	x	x	x	x
Hermit Thrush	R	-	x	x	-	x
Townsends" Solitaire	F	-	x	x	x	x
Golden-crowned Kinglet	F	-	x	x	x	x
Cedar Waxwing	F	x	x	x	x	x
Solitary Vireo	F	-	x	x	x	x
Audubon's Warbler	F	-	x	x	x	x
Western Tanager	F	-	x	x	x	x
Black Headed Grosbeak	F	-	x	x	x	x
Purple Finch	F	-	x	x	x	x
Cassins Finch	F	-	x	x	x	x
Pine Grosbeak	F	x	-	-	-	-
Pine Siskin	F	x	x	x	x	x
Red Crossbill	F	x	x	-	x	-
Green-Tailed Towhee	F	-	-	x	x	x
Oregon Junco	M	-	x	x	-	x
Fox Sparrow	F	-	x	x	-	x

Cascade Foothills (Mixed Conifer)

All the species present in the Pine Plateau plus the following species.

		Use Season				
Species	Population Level	W.	Sp.	S.	F.	Nesting
Ruffed Grouse	F	x	x	x	x	x
Vaux's Swift	R	x	x	x	x	-
Calliope Hummingbird	F	-	x	x	x	x
Belted Kingfisher	F	x	x	x	x	x
Eastern Kingbird	F	-	x	x	x	x
Traills Flycatcher	F	-	x	x	-	x
Hammond's Flycatcher	F	-	x	x	-	x
Black-capped Chickadee	F	x	x	x	x	x
Dipper	F	x	x	x	x	x
Winter Wren	F	x	x	x	x	x
Bohemian Waxwing	F	-	x	x	x	-
Warbling Vireo	F	-	x	x	x	x
Orange-crowned Warbler	F	-	x	x	x	x
Nashville Warbler	F	-	x	-	x	-
MaGillivray's Warbler	F	-	x	x	x	x
Yellow Throat	F	-	x	x	x	x
Yellow-breasted Chat	F	-	x	x	-	x
Lazuli Bunting	F	-	x	x	x	x
Evening Grosbeak	F	-	x	-	x	-
Lesser Goldfinch	F	-	x	x	x	x

Juniper Tablelands

Species	Population Level	Use Season				Nesting	Veg. Type*
		W.	Sp.	S.	F.		
California Quail	F	x	x	x	x	x	B
Sagegrouse	F	x	x	x	x	x	B
Chukar Partridge	F	x	x	x	x	x	B
Mourning Dove	M	-	x	x	-	x	B
Hungarian Partridge	F	x	x	x	x	x	B
Swainson's Hawk	F	-	x	x	x	-	B
Rough-legged Hawk	F	x	x	-	x	-	Sg
Ferruginous Hawk	F	x	-	-	-	-	Sg
Golden Eagle	F	x	x	x	x	x	B
Red-tailed Hawk	F	x	x	x	x	x	B
Prairie Falcon	F	x	x	x	x	x	B
Peregrine Falcon	R	x	x	x	x	x	B
Pigeon Hawk	F	x	x	x	x	x	B
Sparrow Hawk	F	x	x	x	x	x	B
Great Horned Owl	F	x	x	x	x	x	Sg
Burrowing Owl	F	-	-	x	x	x	Sg
Long Eared Owl	R	x	x	x	x	-	B
Turkey Vulture	F	-	x	x	x	x	B
Canada Goose, sp.	F	-	x	-	-	x	Sg
Mallard	F	-	x	-	-	x	Sg
Flicker	F	x	x	x	x	x	Sg
Bewick's Wren	F	x	x	x	x	x	B
Long Billed Curlew	F	-	x	x	x	x	Sg
Poor Will	F	-	x	x	x	x	B
Common Nighthawk	F	-	x	x	x	-	B
Western Kingbird	M	-	x	x	x	x	B
Ash-throated Flycatcher	R	-	x	x	x	x	B
Say's Phoebe	R	-	x	x	x	x	B
Gray Flycatcher	F	-	-	x	-	x	B
Horned Lark	F	-	x	x	x	x	B
Bank Swallow	F	-	x	x	x	x	Sg
Rough-Winged Swallow	F	-	x	x	x	-	Sg
Barn Swallow	F	-	x	x	x	x	Sg
Cliff Swallow	M	-	x	x	x	x	Sg
Scrub Jay	F	x	x	x	x	x	B
Black-billed Magpie	M	x	x	x	x	x	B
Pinion Jay	F	x	x	x	x	x	B
Plain TitMouse	F	x	x	x	x	-	B
Common Bushtit	F	x	x	x	x	x	B
Rock Wren	F	x	x	x	x	x	B
Sage Thrasher	F	-	x	x	x	x	B
Robin	M	x	x	x	x	x	B
Townsend's Solitaire	F	x	-	-	x	-	B
Golden-crowned Kinglet	F	x	-	-	x	-	B
Northern Shrike	F	x	x	-	x	-	Sg

Juniper (cont.)

Species	Population Level	W.	Sp.	S.	F.	Nesting	Type*
Loggerhead Shrike	F	x	x	x	x	x	Sg
Starling	F	x	x	x	x	-	Sg
Lazuli Bunting	R	-	x	x	x	x	Sg
House Finch	F	x	x	x	x	x	Sg
Green-tailed Towhee	R	-	-	x	x	x	B
Savannah Sparrow	M	x	x	x	x	x	Sg
Vesper Sparrow	F	-	x	x	x	x	B
Sage Sparrow	F	-	x	x	x	x	B
Brewers Sparrow	F	x	x	x	x	x	B
Chestnut-collard Longspur	F	x	x	-	x	-	Sg
Lapland Longspur	F	x	x	-	x	-	B
Snow Bunting	F	x	x	-	x	-	B

Valley Bottoms & other Marsh and Water Areas

Bird list prepared by Bureau of Sports Fisheries and Wildlife for the Klamath Basin National Wildlife Refuges. (Refuge Leaflet 104-R-5, June 1969) It is felt that this list is applicable to the entire basin where similar habitat types exist.

The following list contains 249 species recorded on or near the refuges. Twenty-five species considered to occur casually are added in an appendix. The list is in accordance with the Fifth (1957) A.O.U. Checklist. Birds noted as nesting locally are preceded by an *. If a species is apt to be limited to a particular habitat type, location keys (1 to 5) are provided to indicate where the species may be seen.

1 - Upper Klamath
2 - Clear Lake
3 - Lower Klamath
4 - Tule Lake
5 - Klamath Forest

Symbols indicative of the relative abundance of each species are tabulated as follows:

S - March-May
S - June-August
F - September-November
W - December-February

a - abundant
c - common
u - uncommon
o - occassional
r - rare

Species	S	S	F	W
Common Loon	u	o	u	r
*Red-necked Grebe - 1,5		u		
Horned Grebe	o	o		
*Eared Grebe	c	a	a	u
*Western Grebe	c	a	a	u
*Pied-billed Grebe	c	c	c	u
*White Pelican	c	c	c	
*Double-crested Cormorant	c	c	c	r
*Great Blue Heron	c	c	c	c
Green Heron - 1	o	o		
*Common Egret	c	c	c	r
*Snowy Egret	u	c	u	
*Black-crowned Night Heron	c	c	c	u
*Least Bittern	r	r	r	
*American Bittern	c	r	u	o

Valleys (cont.)

Species	S	S	F	W
*White-faced Ibis	u	u	r	
Whistling Swan	c		c	u
Trumpeter Swan	r			r
*Canada Goose (4 subsp.)	a	c	a	c
Black Brant			o	
Emperor Goose	r		o	
White-fronted Goose	a	o	a	u
Snow Goose	a	o	a	u
Blue Goose	r		r	
Ross' Goose	u	o	u	o
*Mallard	a	a	a	c
*Gadwell	c	c	c	o
*Pintail	a	c	a	c
*Green-winged Teal	c	o	a	o
*Blue-winged Teal	o	u	r	
*Cinnamon Teal	c	a	c	r
*American Widgeon	a	o	a	u
*Shoveler	a	c	a	c
*Wood Duck	u	u	u	
*Redhead	c	a	c	u
*Ring-necked Duck	u	u	u	u
*Canvasback	c	u	c	u
Greater Scaup	o		o	
*Lesser Scaup	c	u	a	c
Common Goldeneye	c	r	u	c
Barrow's Goldeneye	o			o
Bufflehead	c	o	c	o
Oldsquaw			o	
White-winged Scoter	r		o	r
Surf Scoter			r	r
*Ruddy Duck	a	c	a	u
*Hooded Merganser	u	u	u	u
*Common Merganser	c	o	a	c
Red-breasted Merganser	r			
*Turkey Vulture	u	u	u	
*Goshawk - 1,5	o	o	o	r
*Sharp-shinned Hawk	o	o	o	r
Cooper's Hawk	o	o	o	o
*Red-tailed Hawk	c	u	c	c
Swainson's Hawk	o	o	o	

Valleys (cont.)

Species	S	S	F	W
Rough-legged Hawk	c		c	c
Ferruginous Hawk			o	
*Golden Eagle	u	o	u	c
*Bald Eagle	c	o	u	a
*Marsh Hawk	c	c	c	c
*Osprey - 1,5	o	o	r	
*Prairie Falcon	u	o	o	o
*Peregrine Falcon	o	r	o	r
*Pigeon Hawk	u	o	u	o
*Sparrow Hawk	c	u	c	c
*Blue Grouse - 1,5	o	o	r	r
*Ruffed Grouse - 1,5	o	o	r	r
*Sage Grouse - 2	u	u	u	u
*California Quail	c	c	c	c
*Mountain Quail - 1	o	o	o	
*Ring-necked Pheasant	c	c	c	c
*Chukar - 3,4	o	o	o	o
*Sandhill Crane	u	u	u	
*Virginia Rail	o	o	o	r
*Sora	o	o	o	r
*American Coot	a	a	a	c
*Snowy Plover	r	r		
*Killdeer	c	c	c	c
Black-bellied Plover	o	o	o	o
Ruddy Turnstone	o		o	
*Common Snipe	u	u	u	r
*Long-billed Curlew	u	u	o	
Whimbrel	r		r	
*Spotted Sandpiper	o	u	o	
Solitary Sandpiper	u	o	u	
*Willet	u	c	u	
Greater Yellowlegs	c	u	c	o
Lesser Yellowlegs	o	o	o	
Knot			r	
Pectoral Sandpiper	r		r	
Least Sandpiper	a	u	a	
Dunlin	c	o	o	

Valleys (cont.)

Species	S	S	F	W
Long-billed Dowitcher	c	c	a	o
Stilt Sandpiper		r	r	
Western Sandpiper	c	c	c	
Marbled Godwit	o	r	r	
Sanderling	r	r		
*American Avocet	c	a	c	r
*Black-necked Stilt	u	c	o	
Red Phalarope	o		o	
*Wilson's Phalarope	o	c	o	
Northern Phalarope	u	o	u	
Herring Gull			o	o
*California Gull	c	a	u	o
*Ring-billed Gull	c	a	c	c
Bonaparte's Gull	o	u	u	
*Forster's Tern	c	a	c	
*Caspian Tern	u	c	u	
*Black Tern	u	a	u	
Bank-tailed Pigeon	r		r	
*Mourning Dove	c	c	c	o
*Barn Owl	u	u	u	u
*Screech Owl - 1,5	o	o	o	o
*Great Horned Owl	u	u	u	u
*Pgymy Owl - 1,5	o	o	o	o
*Burrowing Owl		o	o	
*Great Gray Owl - 1,5	r	r	r	r
Long-eared Owl - 1,5	r	r	r	r
*Short-eared Owl	u	c	c	c
*Saw-whet Owl - 1,5	r	r	r	r
*Poor-will	o	o	o	
*Common Nighthawk	u	a	a	
*Vaux's Swift		o		
*Rufous Hummingbird	o	o	o	
*Calliope Hummingbird - 1		o		

Species	S	S	F	W
*Belted Kingfisher	u	u	u	u
*Red-shafted Flicker	c	c	c	c
*Pileated Woodpecker	o	o	o	o
*Lewis' Woodpecker	o	o	o	
*Yellow-bellied Sapsucker	c	c	c	o
*Williamson's Sapsucker - 1,5	o	o	o	
*Hairy Woodpecker	u	u	u	u
*Downy Woodpecker	u	u	u	u
*White-headed Woodpecker - 1,5	o	o	o	r
*Bb. 3-toed Woodpecker - 1,5	r	r	r	r
Eastern Kingbird	o	o		
*Western Kingbird	c	c	c	
*Ash-throated Flycatcher	o	u	o	
*Say's Phoebe	c	c	c	
*Trail's Flycatcher - 1	o	u	o	
Hammond's Flycatcher		r		
*Dusky Flycatcher - 1		o		
*Gray Flycatcher		c		
*Western Flycatcher	u	u		
*Western Wood Pewee	u	c		
*Olive-sided Flycatcher		o		
*Horned Lark	c	c	c	c
*Violet-green Swallow - 1,5	u	u	u	
*Tree Swallow	c	c	c	
*Bank Swallow	o	c	c	
Rough-winged Swallow	o	u	o	
*Barn Swallow	c	c	c	
*Cliff Swallow	a	a	a	
*Purple Martin		u	u	
*Gray Jay - 1	o	o	o	o
*Steller's Hay - 1,5	u	c	c	u
*Scrub Jay - 2	u	u	u	u
*Black-billed Magpie	c	c	c	c
Common Raven	o	r	o	o

Valleys (cont.)

Species	S	S	F	W
*Common Crow	o	o	o	o
*Pinyon Jay	u	u	u	u
*Clark's Nutcracker - 1,5	o	o	o	o
*Black-capped Chickadee	u	u	u	u
*Mountain Chickadee	u	u	u	u
*Chestnut-backed Chickadee	o	o	o	o
Plain Titmouse	o	o	o	o
*Common Bushtit	u	u	u	o
*White-breasted Nuthatch	o	o	o	o
*Red-breasted Nuthatch	o	o	o	o
*Pigmy Nuthatch - 1	u	u	u	o
*Brown Creeper	u	u	u	o
Wrentit		o	o	
Dipper 1	r	r	r	r
*House Wren	o	u	o	
*Winter Wren - 1	u	u	u	o
Bewick's Wren	r	r	r	r
*Long-billed Marsh Wren	a	a	a	u
*Canyon Wren	u	u	u	u
*Rock Wren	u	u	u	u
*Sage Thrasher	o	u	o	
*Robin	c	c	c	u
Varied Thrush	o		o	
*Swainson's Thrush	u	u		
*Hermit Thrush	o	u		
*Western Bluebird	u	u	u	u
*Mountain Bluebird	u	u	u	u
*Townsend's Solitaire	o	o	o	o

Valleys (cont.)

Species	S	S	F	W
*Golden-crowned Kinglet - 1,5	u	u	u	u
*Ruby-crowned Kinglet	u	c	u	
Water Pipit	c	o	o	o
Bohemian Waxwing	r		r	r
*Cedar Waxwing	u	u	u	u
Northern Shrike	o		o	c
*Loggerhead Shrike	c	c	c	c
*Starling	c	c	c	c
*Solitary Vireo - 1	u	u	u	
*Warbling Vireo - 1	u	c	u	
*Orange-crowned Warbler	u	u	u	
Nashville Warbler - 1	u		u	
*Yellow Warbler	c	c	c	
Myrtle Warbler - 1	r			
*Audubon's Warbler	c	c	c	
*Black-throated Gray Warbler	o	o		
Hermit Warbler - 1		r		
*MacGillivray's Warbler	u	u	u	
*Yellowthroat	u	u	u	
*Yellow-breasted Chat	u	u		
*Wilson's Warbler	u	u	u	
*House Sparrow	c	c	c	c
*Western Meadowlark	c	c	c	c
*Yellow-headed Blackbird	c	c	c	o
*Red-winged Blackbird	a	a	a	c
*Tricolored BLackbird	c	c	u	o
*Bullock's Oriole	c	c	c	

Valleys (cont.)

Species	S	S	F	W
*Brewer's Blackbird	a	a	a	c
*Brown-headed Cowbird	c	c	c	
*Western Tanager	u	c	u	
*Black-headed Grosbeack - 1	u	u	u	
*Lazuli Bunting	u	u	u	
Evening Grosbeak	u		u	o
*Purple Finch - 1,5	o	o	o	o
*Cassin's Finch - 1,5	u	u	u	
*House Finch	c	c	c	c
Pine Grosbeak - 1,5				o
*Pine Siskin - 1,5	u	u	u	u
*American Goldfinch	u	u	u	
*Lesser Goldfinch	o	o	o	o
Red Crossbill	o		o	o
*Green-tailed Towhee		u	o	
*Rufous-sided Towhee	c	u	u	o
Brown Towhee	o	o	o	r
*Savannah Sparrow	c	c	c	c
*Vesper Sparrow	u	c	u	
*Lark Sparrow	u	c	u	
*Sage Sparrow	c	c	c	
Slate-colored Junco	o			o
*Oregon Junco	c	u	c	c
*Chipping Sparrow	u	c	u	o
*Brewer's Sparrow	c	c	u	r
Harris Sparrow			r	r
White-crowned Sparrow	c		c	c
Golden-crowned Sparrow	o		o	
White-throated Sparrow	r		r	r
*Fox Sparrow	u	u	u	o
Lincoln's Sparrow	c	c	c	c
Chestnut-collared Longspur	o		o	o
Lapland Longspur	o		o	o
Snow Bunting	r		r	r

These additional 24 species, generally out of their normal ranges, have been recorded locally. Birds classified as rare in the main list are within their distribution limits but rare for other reasons.

- Artic Loon
- Brown Pelican
- Egyptian Goose
- Bar-headed Goose
- Black Duck
- White-tailed Kite
- Red-shouldered Hawk
- Byrfalcon
- Common Gallinule
- Semipalmated Plover
- Baird's Sandpiper
- Indigo Bunting
- Parasitic Jaeger
- Spotted Owl
- Black Swift
- Yellow-shafter Flicker
- Eastern Kingbird
- Hutton's Vireo
- Red-eyed Vireo
- Townsend's Warbler
- Bay-breasted Warbler
- Bobolink
- Orchard Oriole
- Blue Grosbeak

Fish of Probable Occurrence Within the Potential Klamath Geothermal Study Area

Game Fish

(Cold Water)

- Coho salmon
- Brown trout
- Rainbow trout

(Warm Water)

- Brown bullhead
- Green sunfish
- White crappie
- Yellow perch
- White sturgeon
- Bluegill
- Pumpkinseed
- Black crappie
- Largemouth bass
- Lost River sucker (Mullet)

Non-Game Fish

- Fathead minnow
- Klamath largescale sucker
- Tui chub
- Speckled dace
- Klamath Lake sculpin
- Mosquitofish
- Pit-Klamath brook lamprey
- Klamath smallscale sucker
- Shortnose sucker
- Blue chub
- Slender sculpin
- Marbled sculpin
- Pacific lamprey

For scientific names refer to Keys to Oregon Freshwater Fishes.

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Plant List by Occurence

The major common species of plants are listed according to physiographic unit. Many other species of plants may be found in the study area but their abundance and relative importance is not significant.

Trees

Pine plateau	Cascade foothills	Juniper tablelands	Valleys	Genus	Species	Common Name
x		x		Pinus	ponderosa	Ponderosa pine
	x			Pinus	lambertiana	Sugar pine
	x			Pinus	contorta	Lodgepole pine
	x			Abies	concolor	White fir
	x			Abies	grandis	Grand fir
	x			Abies	magnifica	Red fir
	x			Abies	magnifica var. shastensis	Shasta red fire
	x			Pseudostuga	menziesii	Douglas-fir
	x			Libocedrus	decurrens	Incense cedar
	x			Sorbus	Spp.	Oregon ash
			x	Populus	trichocarpa	Black cottonwood
x	x			Populus	tremuloides	Aspen
	x		x	Quercus	garryana	Oregon white oak
x		x		Juniperus	occidentalis	Western juniper
			x	Misc.	Introduced ornamentals.	
					Shrubs	
x	x			Ceanothus	prostratus	Squaw carpet
x	x			Castanopis	Spp.	Golden chinquapin
	x			Berberis	repens	Oregon grape
	x			Cornus	Spp.	Dogwood
x	x			Arctostaphylos	Spp.	Manzanita
x	x			Ceanothus	Spp.	Ceanothus
x	x	x	x	Salix	Spp.	Willow
x	x	x	x	Rosa	woodsi	Wild rose
x	x			Amelanchier	Spp.	Serviceberry
x	x	x	x	Cercocarpus		Birchleaf mountain mahogany
x	x	x	x	Cercocarpus	ledifolius	Curlleaf mountain mahogany

	x	x		Purshia	tridentata	Antelope bitterbrush
x		x	x	Chrysothamnus	viscidiflorus	Douglas rabbitbrush
		x	x	Chrysothamnus	nauseosus	Rubber rabbitbrush
x	x			Prunus	subcordata	Klamath plum
x	x	x		Ribes	klamathenis	Klamath gooseberry
x	x			Prunus	virginiana	Chokecherry
x	x			Sambucus	flauca	Blue elderberry
x	x	x	x	Artemisia	tridentata	Big sagebrush
		x	x	Artemisia	arbuscula	Low sagebrush
x			x	Artemisia	cana	Silver sagebrush
			x	Other introduced ornamentals		

Forbs

x	x		x	Taraxacum	Spp.	Dandelion
x		x	x	Balsamorhiza		Balsamroot
		x	x	Senecio	Spp.	Groundsel
x			x	Acanthochiton	lanulosa	Western yarrow
x	x			Wyethia		Mules ear
		x	x	Ranunculus	glaberrimus	Sagebrush buttercup
	x		x	Hydrophyllum	Spp.	Waterleaf
				Eriogonum	Spp.	Buckwheat
		x	x	Descurainia	Spp.	Wild mustard
				Brassica	Spp.	
			x	Allium	Spp.	Wild onion
		x		Phlox	hoodii	Phlox - and others
x	x	x	x	Lupinus	Spp.	Lupine
x		x		Vicia	americana	Vetch
		x	x	Pseudocymopteris	Spp.	Wild parsley
x	x		x	Verbascum	thapsus	Mullen
	x		x	Cirsium	Spp.	Star thistle
x	x	x	x	Many others		
x	x			Arnica	Spp.	Heart leaf arnica
x	x			Hesperochiron	Spp.	Hesperochiron
x		x		Perideridia	Spp.	Yampa
x	x			Camissia	Spp.	Camas
		x	x	Calochortus	Spp.	Sego lily
x		x		Zygadenus	Spp.	Death camas
x		x		Antennaria	Spp.	Pussy-toes

Grass and Grass-like* Plants

x		x		Oryzopsis	webberi	Webers ricegrass
		x	x	Agropyron	spicatum	Bluebunch wheatgrass
x	x		x	Poa	secunda	Sandberg bluegrass
			x	Poa	canbyi	Canby bluegrass
x	x	x	x	Festuca	idahoensis	Idaho fescue
		x	x	Helictotrichom	hookeri	Onespike oatgrass
		x	x	Sitanion	hystrix	Squirreltail grass

x		x	x	Stipa	Spp.	Needlegrass
		x	x	Deschampsia	caespitosa	Tuffed hairgrass
			x	Juncus	balticus	Baltic rush*
			x	Carex	geyeri	Elk sedge*
			x	Distichlis	stricta	Inland saltgrass
x		x		Elymus	cinereus	Great Basin wildrye
			x	Sagittaria	latifolia	Arrowhead
			x	Equisetum	Spp.	Horsetails
			x	Eleochario	Spp.	Spike-rush
				Ruppia	Maritima	Widgon grass
x	x	x	x	Bromus	tectorum	Cheatgrass
		x		Bromus	Spp.	Rattlesnake brome

Aquatic Plants

			x	Lemna	minor	Duckweek
			x	Elodea	densa	Elodea
			x	Ceratophyllum	demersum	Coontail
			x	Najas	flexillis	Najas
			x	Potamogeton	natans	Floating redwood
			x	Sparganium	minimum	Bur reed
			x	Utricularus	Spp.	Bladderwart
			x	Potamogeton	natans	Floating - Leaf pondweed
			x	Polygonum	amphibium	Smartweed
			x	Scirpus	Spp.	Bulrush
			x	Equisetum	Spp.	Horsetail
			x	Typha	Latifolia	Cattail
			x	Eichornia	crossipes	Water hyacinth
			x	Nuphar	Spp.	Pondlily
			x	Myriophyllum	Spp.	Water milfoil

ENVIRONMENTAL ANALYSIS WORKSHEET

REMARKS: Environmental Impacts of the Proposed Action:

0 - No Impact	M - Medium Impact	x - Unknown	+ - Beneficial Impact
L - Low Impact	H - High Impact		- - Adverse Impact

STAGES OF IMPLEMENTATION	EXPLORATION					DEVELOPMENT						OPERATION				CLOSE-OUT		
DISCRETE OPERATIONS	Airborne	Off-Road Vehicle Travel	Road & Trail Construction	Drilling	Rehabilitation	Road Construction	Drill Site Development	Geothermal Pipelines	Plant Construction	Electric Transmission Lines	Rehabilitation	New Drill Sites	Mtce. of Existing Facilitie	Waste Desposal	Production	Removal of Surface Equip	Surface Reclam & Restoration	REMARKS
I. NON-LIVING COMPONENTS																		
A. AIR																		
Air Movement Patterns.	0	0	0	0	0	0	0	0	0	0	0	0	x	x	x	0	0	
Temperature	0	0	0	0	0	0	0	0	0	0	0	0	0	x	x	0	0	
Particulate Matter	0	-L	-L	-L	0	-L	-L	-L	-M	-L	+L	-L	0	0	0	-L	+M	Total surrounding area
Noxious Gases	0	-L	-L	-L	0	0	-L	0	0	0	0	-L	x	x	x	0	0	
Non-ionizing Radiation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	x	0	0	
B. LAND																		
Soil Depth	0	0	-L	-L	+L	-M	-L	0	-L	-L	0	-L	0	0	0	-L	0	
Soil Erosion	0	-M	-M	-L	+M	-M	-L	-L	-L	-L	+L	-L	0	0	0	-L	+M	
Soil Structure	0	-L	-L	-L	+L	-M	-L	0	-L	-L	0	-L	0	0	0	-L	0	
Geologic Structure	0	0	0	0	0	0	0	0	0	0	0	0	0	x	x	0	0	
Land Use Compatibility	0	0	-L	-L	+L	-L	0	-L	0	0	0	0	0	x	x	x	M	
Soil Pollutant Properties	0	0	0	x	0	0	-x	0	0	0	0	x	x	-L	x	0	0	

ENVIRONMENTAL ANALYSIS WORKSHEET

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DISCRETE OPERATIONS	Airborne	Off-Road Vehicle Travel	Road & Trail Construction	Drilling	Rehabilitation	Road Construction	Drill Site Development	Geothermal Pipelines	Plant Construction	Electric Transmission Lines	Rehabilitation	New Drill Sites	Mtce. of Existing Facilitie	Waste Desposal	Production	Removal of Surface Equip	Surface Reclam & Restoration	REMARKS
C. WATER																		
Sediment Load	0	-L	-L	-L	0	-L	-L	0	-L	0	0	-L	0	0	0	0	-L	X refers to unknown
Hydrologic Cycle	0	0	0	x	0	-L	0	0	-L	0	0	0	0	-L	+M	0	0	chemical quality of
Dissolved Solids	0	0	0	x	0	0	x	0	0	0	0	x	0	x	x	+L	0	geothermal fluids
Toxic Chemicals	0	0	0	x	0	0	x	0	0	0	0	-L	0	-L	-L	x	0	
Temperature												0	0	x	x	0	0	
Dissolved Oxygen	0	0	0	0	0	0	0	0	0	0	0	0	0	x	0	0	+L	
Radiological Contam.	0	0	0	0	0	0	0	0	0	0	0	0	0	x	0	x	0	
PH	0	0	0	0	0	0	0	0	0	0	0	0	0	x	0	x	0	
II. LIVING COMPONENTS																		
A. PLANTS (AQUATIC)																		
All	0	0	0	0	0	-L	-L	0	0	0	0	0	0	x	0	0	+L	
B. PLANTS (TERRESTRIAL)																		
All	0	-L	-L	-L	+L	-L	-L	-L	-L	0	+L	-L	0	x	0	-L	+M	

ENVIRONMENTAL ANALYSIS WORKSHEET

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STAGES OF IMPLEMENTATION	EXPLORATION					DEVELOPMENT						OPERATION				CLOSE-OUT		
DISCRETE OPERATIONS	Airborne	Off-Road Vehicle Travel	Road & Trail Construction	Drilling	Rehabilitation	Road Construction	Drill Site Development	Geothermal Pipelines	Plant Construction	Electric Transmission Lines	Rehabilitation	New Drill Sites	Mtce. of Existing Facilitie	Waste Desposal	Production	Removal of Surface Equip	Surface Reclam & Restoration	REMARKS
C. ANIMALS (AQUATIC)																		
All	0	-L	-L	-L	0	-L	-L	0	0	0	+L	-L	0	x	0	0	0	
D. ANIMALS (TERRESTRIAL)																		
All Domestic & Wildlife	0	-L	-M	-L	+L	-L	-M	0	-L	x	+L	-L	0	x	x	0	+M	Depends upon exact location
III. ECOLOGICAL INTERRELATIONSHIPS																		
A. ECOLOGICAL PROCESSES																		
Succession	0	-L	-L	-L	x	-L	-L	0	-L	0	x	-L	0	x	0	0	x	
Food Relationships	0	0	-L	0	0	-L	-L	0	-L	0	x	-L	0	x	0	0	+L	
Community Relationships	0	0	-L	0	0	-L	-L	0	-L	0	x	-L	0	x	x	0	0	

ENVIRONMENTAL ANALYSIS WORKSHEET

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STAGES OF IMPLEMENTATION	EXPLORATION					DEVELOPMENT						OPERATION				CLOSE-OUT		
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IV. HUMAN VALUES																		
A. LANDSCAPE CHARACTER																		
Harmonious	0	-L	-M	-L	+L	-M	-M	-M	-H	-M	0	-L	x	x	x	+H	+L	
Accentuating	0	x	x	x	x	0	0	0	0	-M	0	0	0	0	0	0	0	
B. SOCIOCULTURAL INTERESTS																		
Education/ Scientific	0	0	-H	+M	0	-H	+H	0	-H	-M	0	-H	0	0	+M	+H	+H	
Social Welfare	0	0	+L	+L	+L	+L	+M	+L	+M	+M	+L	+L	+L	0	+L	0	+L	
Attitudes & Expectations	0	0	0	+L	0	x	x	x	x	x	x	0	0	0		0	0	
Local Regulatory Struct.	0	0	-L	-L	0	-L	-L	-L	-L	0	0	-L	0	0	0	0	0	
Cultural Values	0	0	-L	-L	0	-L	-L	-L	-L	0	0	-L	0	0	0	0	0	

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